ENVIRONMENTAL ASSESSMENT/REGULATORY IMPACT REVIEW/ INITIAL REGULATORY FLEXIBILITY ANALYSIS OF ALTERNATIVES TO ALLOCATE THE PACIFIC COD TOTAL ALLOWABLE CATCH BY GEAR AND/OR DIRECTLY CHANGE THE SEASONALITY OF THE COD FISHERIES

AMENDMENT 24 TO THE FISHERY MANAGEMENT PLAN FOR THE GROUNDFISH FISHERY OF THE BERING SEA AND ALEUTIAN ISLANDS AREA

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NOTE: The appendices to this document are in a separate volume.

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EXECUTIVE SUMMARY FOR BSAI AMENDMENT 24

ALLOCATING THE PACIFIC COD TAC BY GEAR AND/OR DIRECTLY CHANGING THE SEASONALITY OF THE COD FISHERIES

BACKGROUND

With the exception of sablefish, no BSAI groundfish TAC is allocated explicitly by gear. At its January 1992 meeting, the Council asked staff to prepare an amendment package that included alternatives to establish fixed allocations of the Pacific cod TAC by gear. The Council's request was, in part, the result of a proposal it received from the North Pacific Fixed Gear Coalition that proposed that fixed gear operators be given preferential access to certain groundfish species in the BSAI.

At the September 1992 meeting, the Council reviewed the preliminary analysis of allocating the BSAI Pacific cod TAC among gear types. Based in part on deficiencies that were discussed in the initial Draft, the AP and SSC recommended that those deficiencies be eliminated and that a revised draft be prepared. The Council accepted these recommendations, asked that the revised draft include an analysis of alternatives designed explicitly to change the seasonality of the cod fisheries, and asked that the revised draft be available in time for the Council to decide at its April 1993 meeting whether to release it for public comment.

A Council review draft was prepared by a staff analytical team in response to the direction provided by the Council in September. It provided an evaluation of the efficacy and the potential biological and socioeconomic impacts of establishing a fixed allocation of the Pacific cod TAC by gear and/or explicitly changing the seasonality of the cod fisheries. After reviewing that draft in April, the Council: (1) developed a problem statement for Amendment 24; (2) stated that unless the Council was presented with substantial consensus among major industry components, it would be unlikely to take any action on this amendment; and (3) voted to have the draft released for public review after it is modified both to address jig gear and to include 1993 data to the extent possible.

At its June 1993 meeting, the Council adopted a preferred alternative for the allocation of the Pacific cod TAC among operators of vessels using trawl, jig, and hook-and-line or pot gear. The Council also recommended that the amount of Pacific cod allocated to vessels using hook-and-line or pot gear be seasonally apportioned among seasons. A discussion of the Council's preferred alternative is presented in Section 1.6 of this document.

PROBLEM STATEMENT

Alternatives to establish explicit allocations by gear and/or to directly change the seasonality of the cod fisheries are being considered because the existing authority to establish PSC allowances by fishery and season may not be adequate to address the following problem statement developed by the Council at its April 1993 meeting.

The Bering Sea/Aleutian Islands Pacific cod fishery, through overcapitalized open access management, exhibits numerous problems which include compressed fishing seasons, periods of high bycatch, waste of resource, gear conflicts and an overall reduction in benefit from the fishery. The objective of this amendment is to provide a bridge to comprehensive rationalization. It should provide a measure of stability to the fishery while allowing various components of the industry to optimize their utilization of the resource.

ALTERNATIVES

Two types of changes are being considered. They are:

1. Establishing explicit allocations of the BSAI cod TAC either among the trawl, longline, jig, and pot groundfish fisheries or among groups of these fisheries; and

2. Changing the seasonality of the BSAI cod fisheries by:

   a. Changing the fishing season for Pacific cod from January 1-December 31 to September 1-August 31; and/or

   b. Establishing an explicit distribution of the cod TAC among the following seasons: January-May, June-August, and September-December.

The fishing season can be changed with a regulatory amendment. The other changes would require an FMP amendment. The Council can consider making one, both, or neither of these two types of changes.

With respect to establishing explicit allocations by gear, the options considered range from only bycatch amounts of cod for the trawl fisheries to only bycatch amounts of cod for the longline, jig, and pot fisheries. Based on 1992 data, the range of allocations of the cod TAC to the trawl fishery would be from between 20.6 percent and 23.3 percent to over 99 percent.

Three processes are being considered for changing the seasonal allocation once it is established. They are:

1. An FMP amendment;

2. A regulatory amendment, and

3. A framework that could be used annually.

Although the problem being addressed is the potential of a suboptimal allocation of the cod TAC among fisheries and seasons, and although a market solution, such as the use of individual transferable quotas (ITQs), may be expected to provide a better long-term solution to this problem, ITQs are not being considered as an alternative at this time. This alternative was not suggested by those who have asked for explicit allocations, it was not identified as an alternative by the Council, and it is a sufficiently complex alternative that it could take several years to develop and implement.

SCHEDULE

The tentative schedule is as follows:

May 1993	Release draft for public review
June 1993	Final Council action on Amendment 24
September 1993	Implementation of FMP and regulatory changes recommended by the Council and approved by the Secretary with an Emergency Rule (ER) if the criteria for an ER are met
January 1994	Implementation of FMP and regulatory changes recommended by the Council and approved by the Secretary without an Emergency Rule.

ISSUES CONSIDERED

The summaries of the biological, economic, and social analyses of the alternatives are presented in Chapter 4 by topic. Many of the summaries are based on information contained in Chapters 2 and 3 and Appendices A-I. Due to the large number of topics that were addressed, this executive summary includes an outline of the topics but not topic summaries.

A. EXPECTED EFFECTS ON THE BIOLOGICAL PRODUCTIVITY OF THE BSAI COD RESOURCE

1. Effect on yield per recruit
2. Effects on stock size and equilibrium yield
3. Effects on spawning success
4. Effect on the ability to monitor successfully the attainment of the TAC

B. OTHER BIOLOGICAL EFFECTS

1. Expected effects on marine mammals and seabirds
2. Impacts of trawling on the seabed and benthic community
3. Expected effects of changes in the bycatch of prohibited species

C. EXPECTED EFFECTS ON COASTAL COMMUNITY STABILITY

1. Seasonal stability
2. Levels of economic activity associated with the three cod fisheries
3. Short-term economic viability of the three cod fisheries
4. Long-term economic viability of the three cod fisheries

D. HISTORICAL USE OF THE COD FISHERY

1. Summary of cod catch by gear
2. Summary of cod catch by fishery

E. CURRENT DEPENDENCE ON THE COD FISHERY

F. EXPECTED EFFECTS ON ECONOMIC BENEFITS TO THE NATION

G. LIMITATIONS OF THE ESTIMATES OF NET BENEFITS PER METRIC TON OF COD CATCH (ANB) BY FISHERY AND SEASON

H. IMPLICATIONS OF ANB ESTIMATES BASED ON VARIABLE COST MODEL 2 AND THE HIGHER ESTIMATES OF THE COST OF PROHIBITED SPECIES BYCATCH

I. AN OPTIMAL SOLUTION WITH RESPECT TO NET BENEFITS FROM THE COD FISHERIES

J. EXPECTED DISTRIBUTION EFFECTS

K. OTHER TYPES OF EFFECTS

1. Expected effects on consumers
2. Expected effects on competitiveness of the U.S. fishing industry
3. Expected effects on reporting, management, enforcement, and information costs
4. Differences in the quantity and quality of biological data from the cod fisheries
5. Gear conflicts and vessel safety
6. Effects on other fisheries
7. Fairness and equity

L. ATTAINMENT OF OY WITH EXISTING PSC LIMITS

M. DIFFICULTIES ASSOCIATE WITH CHANGING THE FISHING YEAR FOR PACIFIC COD TO SEPTEMBER - AUGUST

1. Exceed cod TAC and cod fishery PSC allowances in transition year.
2. Options to have a cod TAC and cod fishery PSC allowances in place by September 1. The options are:
    a. Change the schedule for establishing the cod TAC and PSC allowances or
    b. Change the date and process for establishing an interim cod TAC and associated PSC allowances.

N. OPTIONS FOR CHANGING THE ALLOCATION OF THE COD TAC AMONG SEASONS ONCE THE INITIAL ALLOCATION HAS BEEN ESTABLISHED

O. BENEFITS OF EXPLICIT ALLOCATIONS BY FISHERY WITH RESPECT TO ESTABLISHING OPTIMAL SEASONS FOR EACH FISHERY

P. ALLOCATING THE TAC BY SEASON AND CHANGING THE COD FISHING YEAR TO SEPTEMBER-AUGUST

1.0 INTRODUCTION

1.1 Management Background

The eastern Bering Sea groundfish fisheries in the exclusive economic zone (EEZ) are managed under the Fishery Management Plan for the Groundfish Fishery in the Bering Sea/Aleutian Islands Area (BSAI). The fishery management plan (FMP) was prepared by the North Pacific Fishery Management Council (Council) under the Magnuson Fishery Conservation and Management Act (Magnuson Act). The FMP was approved by the Secretary of Commerce and became effective in 1982.

With the exception of sablefish, no BSAI groundfish total allowable catch (TAC) is allocated explicitly by gear. At its January 1992 meeting, the Council asked staff to prepare an amendment package that included alternatives to establish fixed allocations of the Pacific cod TAC by gear. The Council's request was, in part, the result of two proposals it received in response to its annual solicitation for amendment proposals. The North Pacific Fixed Gear Coalition proposed that fixed gear operators be given preferential access to certain groundfish species in the BSAI - initially, Pacific cod, sablefish, and turbot. A similar proposal was included in the Ad Hoc Bycatch Committee's list of 24 proposals. Because the proposal was not given a sufficiently high priority to be developed as part of the Council's annual amendment cycle, its development was delayed until other management issues had been addressed.

The Council reviewed the initial Draft EA/RIR/IRFA in September 1992. Based in part on deficiencies that were discussed in the draft, the Advisory Panel (AP) and Scientific and Statistical Committee (SSC) recommended that those deficiencies be eliminated and that a revised draft be prepared for the Council. The Council accepted these recommendations, asked that the revised draft include an analysis of alternatives designed explicitly to change the seasonality of the cod fisheries, and asked that the revised draft be available in time for the Council to decide at its April 1993 meeting whether to release it for public comment.

A Council review draft was prepared by a staff analytical team in response to the direction provided by the Council in September. It provided an evaluation of the efficacy and the potential biological and socioeconomic impacts of establishing a fixed allocation of the Pacific cod TAC by gear and/or explicitly changing the seasonality of the cod fisheries. After reviewing that draft in April, the Council: (1) developed a problem statement for Amendment 24; (2) stated that unless it is presented with substantial consensus among major industry components, it would be unlikely to take any action on this amendment; and (3) voted to have the draft released for public review after it is modified both to address jig gear and to include 1993 data to the extent possible. The information concerning the jig fishery and the 1993 cod fisheries are in an addendum to this public review draft.

The Council took final action on this amendment in June 1993. A discussion of the Council's preferred alternative is presented in Section 1.6 of this document.

1.2 Purpose of the Document

This document provides background information and assessments necessary for the Secretary of Commerce to determine if the alternatives of Amendment 24 are consistent with the Magnuson Act and other applicable law. It also provides the public with information to assess the alternatives that the Council is considering and to comment on the alternatives. These comments will enable the Council and Secretary to make a more informed decision concerning the resolution of the management problems being addressed. The purpose of this document is to provide information for the decision making process, not to provide a vehicle for justification of a proposed regulatory change. The Council will provide the necessary rationale for its final recommendations in a separate document.

1.2.1 Environmental Assessment

An environmental assessment (EA) is required by the National Oceanic and Atmospheric Administration (NOAA) in compliance with the National Environmental Policy Act of 1969 (NEPA). The purpose of the

EA is to determine whether significant impacts on the quality of the human environment could result from a proposed action. The environmental analysis in the EA provides a basis for this determination and must consider the intensity and severity of the impact of the action and the significance of an action with respect to society as a whole, the affected region and interests, and the locality. If the action is determined not to be significant based on an analysis of relevant considerations, the EA and resulting finding of no significant impact (FONSI) would be the final environmental documents required by NEPA. An environmental impact study (EIS) must be prepared if the proposed action may cause a significant impact on the quality of the human environment.

The potential environmental effects of the alternatives being considered are summarized in Chapter 3. The summaries are based on information contained in Appendices E-I. The types of environmental effects that are addressed and the methods used to address them are discussed in Section 1.5.

1.2.2 Regulatory Impact Review and Initial Regulatory Flexibility Analysis

A Regulatory Impact Review (RIR) is required by the National Marine Fisheries Service (NMFS) for all regulatory actions or for significant Department of Commerce or NOAA policy changes that are of significant public interest. The RIR: (1) provides a comprehensive review of the level and incidence of impacts associated with a proposed or final regulatory action; (2) provides a review of the problems and policy objectives prompting the regulatory proposals and an evaluation of the major alternatives that could be used to solve the problems; and (3) ensures that the regulatory agency systematically and comprehensively considers all available alternatives so that the public welfare can be enhanced in the most efficient and cost effective way.

The RIR also serves as the basis for determining whether any proposed regulations are significant under criteria provided in Executive Order 12866 and whether or not proposed regulations will have a significant economic impact on a substantial number of small entities in compliance with the Regulatory Flexibility Act (P.L. 96-354, RFA). The primary purpose of the RFA is to relieve small businesses, small organizations, and small governmental jurisdictions (collectively, "small entities") of burdensome regulatory and record-keeping requirements. This Act requires that the head of an agency must certify that the regulatory and record-keeping requirements, if promulgated, will not have a significant effect on a substantial number of small entities or provide sufficient justification to receive a waiver.

The potential economic effects of the alternatives being considered are summarized in Chapter 4. The summaries are based both on information presented in Chapters 2 and 3 and on information contained in Appendices A-I. The types of economic effects that are addressed and the methods used to address them are discussed in Section 1.5.

1.3 Purpose of and Need for the Proposed Action

The Pacific cod TAC is taken principally as catch in the trawl, longline, and pot cod fisheries and as bycatch in other trawl groundfish fisheries. Currently, there is not an explicit allocation of the BSAI Pacific cod TAC by either gear or season. Each year the distribution of cod catch by gear and season is determined by the pace at which fishermen harvest cod in the various groundfish fisheries. The pace or rate of harvest in each groundfish fishery is determined in part by the existing fishery regulations. These include the prohibited species catch (PSC) limits for the trawl and non-trawl fisheries, the apportionments of these limits among specific fisheries and seasons, time/area closures, gear restrictions, and TACs for other groundfish species. Under existing regulatory authority, the Secretary, in consultation with the Council, annually apportions the PSC limits among specific fisheries by season. The fisheries for which separate PSC allowances are determined annually include the cod longline and cod trawl fisheries. This authority was used for the first time to specifically limit halibut bycatch and cod catch in the cod trawl and hook and line fisheries for 1993.

The rate of cod harvest in each fishery is also influenced by economic variables such as harvesting and processing costs, exvessel and wholesale prices, and the harvesting and processing capacities of the various groundfish fisheries. Environmental and ecological factors also influence the rate at which cod are taken in

each fishery.

Alternatives to establish explicit allocations by gear and/or to directly change the seasonality of the cod fisheries are being considered because the existing authority to establish PSC allowances by fishery and season may not be adequate to address the following problem statement developed by the Council at its April 1993 meeting.

> The Bering Sea/Aleutian Islands Pacific cod fishery, through overcapitalized open access management, exhibits numerous problems which include compressed fishing seasons, periods of high bycatch, waste of resource, gear conflicts, and an overall reduction in benefit from the fishery. The objective of this amendment is to provide a bridge to comprehensive rationalization. It should provide a measure of stability to the fishery while allowing various components of the industry to optimize their utilization of the resource.

Based on this problem statement, the Magnuson Act national standards, the Council's Comprehensive Fishery Management Goals, and goals and on the Council's most recently established goal to prevent the preemption of one sector by another, the evaluation of the alternatives will be in terms of:

1. Coastal community stability;

2. Historical use of the fishery;

3. Current dependence on the fishery;

4. Bycatch of prohibited species and other species;

5. The biological productivity of the cod stocks;

6. Increased economic benefits to the Nation;

7. Marine mammals and seabirds;

8. Habitat and its productivity; and

9. Social factors.

Often, the attainment of one management goal can be in conflict with the attainment of other goals and fishery managers must make some trade-offs among their goals. This document attempts to provide information on the consequences of alternative management actions so that the trade-offs among the goals can be considered in selecting the preferred alternative.

1.4 Alternatives

The Council is considering two types of changes. One would establish explicit allocations of the cod TAC either among the trawl, longline, jig, and pot groundfish fisheries or among groups of these fisheries. The other type of change would change the seasonality of the cod fisheries by changing the fishing season for Pacific cod from January 1-December 31 to September 1-August 31 and/or by establishing an explicit distribution of the cod TAC among the following seasons: January-May, June-August, and September-December. The fishing season can be changed with a regulatory amendment. The other changes would require an FMP amendment. The Council is considering making one, both, or neither of these two types of changes.

With respect to establishing explicit allocations by gear, the options considered range from only bycatch amounts of cod for the trawl fisheries to only bycatch amounts of cod for the longline, jig, and pot fisheries. The blend estimate of total cod catch for 1992 is 205,326 metric tons (mt) and the TAC was 182,000 mt.

The blend estimate of cod bycatch in other trawl fisheries is 42,387 mt. This is 20.6 percent of the total cod catch or 23.3 percent of the cod TAC. The blend estimate of cod bycatch with all non-trawl gear is 355 mt. This is about 0.17 percent of the total cod catch or 0.20 percent of the cod TAC. Using these data, the range of allocations of the cod TAC to the trawl fishery would be from between 20.6 percent and 23.3 percent to over 99 percent. The Council may establish separate allocations either for each of the four types of gear or for explicit groups of gear.

Three processes are being considered for changing the seasonal allocation once it is established. They are: (1) an FMP amendment, (2) a regulatory amendment, and (3) a framework that could be used annually.

The existing authority to control the distribution of cod catch by gear and season, details of the changes being considered, the reasons that these changes are being considered, and the potential effects of these changes are discussed in subsequent Chapters.

Although the problem being addressed is the potential of a suboptimal allocation of the cod TAC among fisheries and seasons, and although a market solution, such as the use of individual transferable quotas (ITQs), may be expected to provide a better long-term solution to this problem, ITQs are not being considered as an alternative at this time. This alternative was not suggested by the those who have asked for explicit allocations, it was not identified as an alternative by the Council, and it is a sufficiently complex alternative that it could take several years to develop and implement.

1.5 Methods of Analyses

The types of environmental and economic effects that are addressed and the methods used to address them are discussed below.

1.5.1 Methods of analyses of environmental effects

The yield per recruit effects of alternative fishery and season allocations are evaluated using a biological model. Literature reviews are used to address (1) the potential habitat effects of bottom trawl gear and (2) the sustainable yield effects of targeting on prespawning or spawning aggregations. A theoretical biological model is also used to consider some of the latter effects. Observer Program data are used to address potential effects on marine mammals and seabirds.

1.5.2 Methods of analyses of economic effects

The alternatives being considered can have effects on both the level and distribution of the net benefit to the Nation of the cod fisheries. They can affect the overall size of the "pie" and the sizes of the pieces received by various groups. Both types of effects are considered in this document.

Both the net benefits from the cod fisheries and the distribution of those benefits are expected to change whether or not the management regime is changed. The economic analysis attempts to provide comparisons between what will happen with and without specific regulatory changes not comparisons between the current and future fisheries.

Cod harvests in the cod trawl, longline, jig, and pot fisheries of the BSAI are four alternative uses for cod, each of which results in the production (output) of valuable food products from both cod and from the other groundfish species harvested as bycatch in the cod fisheries. Each use of cod also requires the use of a variety of inputs that are of value to society. In addition to the cod, the inputs used in these fisheries include groundfish and prohibited species bycatch; fishing vessels, gear, and bait used in harvesting; the plant, equipment and materials used for processing; and the fuel and labor used throughout the production process. Each of the three cod fisheries uses a different combination of these inputs to produce a different combination of cod and other groundfish products.

The difference between the values of the outputs (revenues) and inputs (costs) for a particular use provides a measure of the net benefit of that use. Revenues are generated from sales of cod and other groundfish products and costs include the value of the inputs used to produce the fishery products. Estimates of net benefits provide a means of comparing alternative uses of cod because the sum of net benefits under various scenarios about harvest distribution among the three cod fisheries and seasons provides an estimate of the overall net benefit of the cod fishery.

In terms of economic efficiency or the size of the pie, a change in the mix of uses is desirable if it increases net benefit to the Nation, that is, if it results in an increase in the difference between output and input values. If it does, the size of the pie is increased, the winners gain more than enough to compensate those who lose, and everyone could be made better off. Alternatively, if the change in the mix of uses results in the winners gaining more than enough to compensate those who lose, the size of the pie has increased and there are positive net benefits. Whether everyone actually gains or whether some actually lose depends on the distribution of the increase in net benefits. Therefore, the expected efficiency and distribution effects of the alternatives being considered jointly determine the optimal alternative.

Economic analysis can be used to estimate the efficiency effects and distribution effects of an alternative. To the extent that it can rank accurately the alternatives in terms of net benefits, it can identify the preferred alternative in terms of economic efficiency. However, economic analysis by itself cannot be used to rank the alternatives in terms of their distribution effects. This is because there is no objective way to evaluate the merits of alternative distributions of income or benefits. The ranking of alternatives in terms of the distribution of benefits requires the use of value judgments concerning the relative merits of benefits to different groups of individuals.

There are at least two ways that the efficiency analysis and distribution analysis can be used jointly by decision makers. First, once the merits of the distribution effects of a specific change from the status quo are determined either collectively or individually by the decision makers, the estimate of the difference in net benefits between that alternative and the status quo can be used by the decision makers as a measure of the cost of obtaining that distribution change. This provides a basis for deciding whether to recommend that alternative. Second, once a distribution objective is set, efficiency analysis can be used to estimate the cost of alternative methods of obtaining that objective.

If transferable property rights were assigned in the groundfish fishery, and participants were responsible for all external costs associated with commercial fisheries, after the initial allocation, the cod and other groundfish TACs would be allocated by the market mechanism. Differences between the values of outputs and inputs for alternative uses of cod would be apparent in the market solution. Specifically, the market mechanism would tend to allocate the cod TAC to the use with the largest difference between marginal output and marginal input values. That difference is the marginal net benefit of a specific use of cod. If both inputs and outputs are valued correctly, the market solution generates the greatest net benefits. It does not, however, assure a distribution of benefits that are socially optimal.

For the analysis in this document, marginal output value is the FOB Alaska value of the fishery products resulting from an additional mt of cod catch and the associated groundfish bycatch. Similarly, marginal input value is the value of the inputs used both to harvest that additional ton of cod and the associated groundfish bycatch and to process them into the resulting fishery products. Due to data limitations, it is assumed that the marginal input and output values are constant and equal, respectively, to the average input and output values. Therefore, for each of the three cod fisheries and seasons, the marginal net benefit equals the average net benefit for that cod fishery and season and estimates of the average net benefits for the three cod fisheries by season can be used to estimate both the direction and magnitude of the change in net benefits associated with a given change in the allocation of a cod TAC among the three fisheries and/or among the seasons.

An economic model is used to estimate the net benefits per mt of cod catch by cod fishery and season in 1991 and 1992 using 1991-92 FOB Alaska processed product prices. Once 1993 prices have become more stable, they will also be used. The model provides an estimate of the difference between the value of the inputs and

the value of outputs for each of three cod fisheries for each season. It, therefore, provides a basis for estimating the effects on net benefits to the Nation of a specific change in the distribution of cod catch by cod fishery and/or season. The model attempts to capture the effects on net national benefits of gear-specific and season-specific differences in harvesting and processing costs, discard rates for cod and other groundfish, processed product mixes and prices, product recovery rates, and bycatch rates for groundfish and prohibited species.

There are principally seven reasons why the estimates of net benefits per mt of cod catch may only be able to indicate whether there are large differences among the three cod fisheries and/or seasons with respect to average net benefits. They are listed below and are discussed more thoroughly in Chapters 2 and 4.

1. Neither the Council nor NMFS has established the ongoing data collection programs required to measure historical net benefits.

2. The allocation of some costs to a cod fishery is problematical for harvesting or processing operations that participate in multiple fisheries.

3. Neither the opportunity cost of using vessels and processing plants nor the time path of replacement costs is known.

4. The assumption of constant average input and output values is a gross simplification.

5. Estimates of net benefits per mt of cod catch provide a basis for partial equilibrium analysis but not for general equilibrium analysis of the alternatives. The difference between the two is that the former considers only changes in the cod fisheries but the latter also considers the resulting effects on other fisheries and other sectors of the economy that would result, for example, from the redeployment of fishing effort in the cod fishery to other fisheries. The development of a general equilibrium model for the fisheries was not possible given the time and resources that were available to evaluate the alternatives being considered. However, many of the effects that are not captured by the partial equilibrium model, that is used, are addressed separately.

6. Changes in net benefits beyond primary processing are ignored. Although the availability of alternative sources of fishery and non-fishery food products suggests that any resulting change either in producer surplus beyond primary processing or in consumer surplus would not be substantial, the potential changes in such surpluses remain an empirical question.

7. The usefulness of even accurate estimates of historical net benefits is reduced substantially by the variability in the factors that jointly determine net benefits per mt of cod catch.

The historical data presented in Chapter 2 are also used to evaluate the alternatives in terms of other types of economic effects. Specifically, the data also are used to address the following issues (1) coastal community stability, (2) historical use of the fishery, (3) current dependence on the fishery, and (4) other social factors. The summaries for these other economic effects are in Chapter 4.

1.6 The Preferred Alternative for Amendment 24

This section of the EA/RIR/IRFA for Amendment 24 to the BSAI Groundfish FMP identifies the Council's preferred alternative and briefly summarizes the expected effects of that alternative. The preferred alternative is within the range of the alternatives evaluated in the draft EA/RIR/IRFA (May 14, 1993) and its Addendum (June 18, 1993).

1.6.1 General description and discussion

At its June 1993 meeting, the Council identified its preferred alternative and voted to submit it to the Secretary of Commerce. The preferred alternative is described below.

1. The BSAI ITAC for Pacific cod, and subsequent allocations of Pacific cod from the operational reserves, will be as follows: 2 percent for groundfish jig gear fisheries, 44.1 percent for the groundfish longline (i.e., hook-and-line) and pot gear fisheries, and 53.9 percent for the groundfish trawl gear fisheries. All cod catch and cod bycatch by each of the three groundfish gear groups will be counted against its allocation.

2. During the September-December specification process, the Secretary, in consultation with the Council, may apportion the longline and pot gear allocation by season. The seasons are January-May, June-August, and September-December.

3. The Regional Director will have the authority to reallocate to other gear groups that portion of a gear group's allocation that is not expected to be used.

4. These three changes will sunset December 31, 1996.

The Council took other actions that were related to but not part of Amendment 24. They are listed below.

1. The Council recommended that each vessel less than 125 ft and greater than 42 ft be required to have at least 30 percent observer coverage during the time it participates in the BSAI cod fishery.

2. The Council asked staff to begin the analysis for a regulatory amendment that would require the use of 8 in square or larger mesh in the BSAI cod trawl fishery.

3. The Council asked staff to begin the analysis for FMP amendments to require retention of all catch in the BSAI and GOA groundfish fisheries. There is no further consideration of these three actions in this document.

The preferred alternative is intended to meet the objective as stated in the following problem statement that was developed by the Council at its April 1993 meeting.

> The Bering Sea/Aleutian Islands Pacific cod fishery, through overcapitalized open access management, exhibits numerous problems which include compressed fishing seasons, periods of high bycatch, waste of resource, gear conflicts, and an overall reduction in benefit from the fishery. The objective of this amendment is to provide a bridge to comprehensive rationalization. It should provide a measure of stability to the fishery while allowing various components of the industry to optimize their utilization of the resource.

By establishing fixed allocations of the Pacific cod TAC among vessels using trawl, longline or pot, and jig gear, the Council's preferred alternative provides stability in terms of the distribution of catch between the trawl and non-trawl fisheries. The Council recommended that 53.9 percent of the Pacific cod TAC be allocated to the trawl fisheries. This is approximately equal to the average percent of cod taken with trawl gear during the last 3 years (1991-93). It is also approximately equal to the 1992 adjusted percent taken with trawl gear. The percent of total cod catch accounted for by each fishery each year is as follows:

	Pacific Cod Fisheries			Other	Total
	Longline	Pot	Trawl	Fisheries	
1990	28.3	0.8	51.8	19.0	100.0
1991	36.5	3.1	41.3	19.1	100.0
1992	49.1	6.7	23.3	20.8	100.0
1992 adj	39.2	7.4	30.2	23.2	100.0
1993	38.9	1.4	36.3	23.4	100.0

The "other fisheries" are almost exclusively non-cod trawl fisheries. The "1992 adj" estimates are of what would have happened had the halibut PSC limits for the cod trawl and longline fisheries been in place at the beginning of the year and had the blend estimates of catch been used to monitor PSC limits and the cod TAC.

It is not known whether the fixed allocation will increase or decrease future non-trawl catch in comparison to what it would be in the absence of this action. However, the non-trawl allocations and the authority to apportion the longline and pot allocation by season are complementary actions that will allow the seasonality of the Pacific cod longline and pot fisheries to be changed in a way that will increase the average net benefit of cod taken in these fisheries.

In the absence of an explicit allocation of cod by fishery, the catch in each fishery is determined by: (1) the cod TAC; (2) the amount of cod that is taken in the other cod fisheries before they are closed by their halibut PSC limits; (3) the amount of cod that is expected to be taken as bycatch in other fisheries (principally non-cod trawl fisheries); (4) its own halibut PSC limit; and (5) the pace at which cod is harvested in each fishery, particularly if the PSC limits do not constrain catch.

If each cod fishery has an explicit share of the cod TAC, a seasonal apportionment can be set for each fishery that would allow it to increase the benefits it can derive from that level of catch. The optimal seasonal apportionments for each fishery, which would be determined by biological, environmental, regulatory, and market conditions, could change annually and could differ substantially from the current seasonal distribution. In the absence of explicit allocations by fishery, common seasons are required and agreement on optimal common seasons is expected to be very difficult. This was demonstrated in late 1992 when the Council was unable to agree on a season change for 1993.

The strong preference by the trawl fishery for cod early in the year eliminates the potential benefit of changing the seasonality of that fishery. Seasonal differences in halibut bycatch rates, product quality, and markets make the second season the least advantageous period for the longline fishery. The seasonality of the BSAI crab fisheries, which are the principal fisheries for most of the vessels that take cod with pot gear, makes the end of the first season, the second season, and the beginning of the third season desirable for the pot fishery. The potential differences in the optimal seasonal apportionments for cod longline and pot fisheries may make it difficult to establish seasonal apportionments that are acceptable to both longline and pot fishermen. The lack of separate allocations for each of these two cod fisheries will add to this problem by making it difficult to assure that any second season (summer) apportionment would be reserved principally for the pot fishery.

The biological and economic analyses do not indicate that a change in the allocation of the cod TAC among the gear groups would result in net benefits to the Nation (see items 1-18 below). However, by providing stability and the authority to seasonally apportion the longline and pot allocation, the preferred alternative provides the potential for each gear group to increase the average benefits received from its cod catch. An additional advantage of the explicit gear allocation is that it eliminates or reduces substantially the justification for using the halibut PSC limit apportionment process to allocate cod between the trawl and non-trawl fisheries. That was a time consuming and contentious process for allocating cod, it added to the difficulties of the September to December specification process, and it was not supported by the analysis and review that such allocation decisions deserve.

Although the preferred alternative approximately maintains the current allocation of cod between the trawl and non-trawl fisheries, it allows a substantial increase in the share of the non-trawl catch taken with jig gear. It is not clear that the 2 percent allocation for the jig fishery will be used fully. If it is not, the expected excess will be reallocated to the fixed gear and trawl fisheries. To the extent that the jig gear allocation is used, the preferred alternative will tend to increase participation by smaller and Alaska based vessels. It is not known whether the current participants in the jig gear fishery or new entrants will account for most of the increase in jig gear catch. The effect on halibut bycatch is not clear. The nature of the jig fishery is expected to result in low halibut bycatch and discard mortality rates. Although there is substantial information from jig fisheries elsewhere in the world to support this expectation, there is very limited observer data for either the BSAI or GOA.

1.6.2 Expected biological, social, and economic effects

The principal benefits from the preferred alternative are in terms of the stability it provides and the ability to shift longline catch from the second to third season, if the longline and pot gear apportionment is not all taken during the first season. This statement is supported by the following 18 points which summarize information presented in Chapter 4 of the EA/RIR/IRFA. That information is based on data and analyses contained in Chapters 2 and 3 and Appendices A-I. The limitations of the analyses are discussed in detail in Chapters 1-4 and in the Appendices. They are not repeated here.

1. Expected Effects on the Biological Productivity of the BSAI Cod Resource

The distribution of cod catch among the cod fisheries and among seasons may affect the biological productivity of the BSAI cod resource through its effects on yield per recruit and due to the effects of fishing on pre-spawning or spawning aggregations of cod. The latter includes direct effects on stock size, equilibrium yield, spawning success, and the ability to monitor successfully the attainment of the TAC.

There are two reasons why the preferred alternative is not expected to have a significant effect on the biological productivity of the BSAI cod resource. First, the preferred alternative is expected to result in very little change in the distribution of cod catch by gear or season. Second, substantially larger changes in the distribution of catch by gear and season are not expected to have measurable effects on the cod resource.

2. Expected Effects on Marine Mammals and Seabirds

A change in the distribution of cod catch among fisheries and/or seasons that has adverse effects on marine mammals and seabirds can impose two types of economic costs. It can decrease the value of the those marine resources and it can result in more costly restrictions being placed on the commercial fisheries. However, the current cod fisheries' interactions with marine mammals and seabirds are not thought to be large enough to have statistically significant effects on their populations. The differential effects between the status quo and the preferred alternative are even smaller. Therefore, the preferred alternative is not expected to differ significantly from the status quo with respect to effects on marine mammal and seabird populations.

3. Impacts of Trawling on the Seabed and Benthic Community

Even if trawling had a demonstrated effect on the seabed and benthic community, the preferred alternative would be expected to have little or no effect because the preferred alternative is not expected to have a significant effect on the level of trawling in the cod or other groundfish fisheries.

4. Expected Effects of Changes in the Bycatch of Prohibited Species

The authority provided by the preferred alternative to allocate the longline and pot gear cod apportionment by season is expected to shift some longline cod catch from the second season to the third season. This will tend to decrease halibut bycatch mortality in the longline fishery.

The current levels of prohibited species bycatch in the cod fisheries are expected to decrease catch in the fisheries that target on these species but not decrease the long-term productivity of the stocks. Although there can be exceptions in which bycatch in the cod fisheries could have an adverse effect on long term productivity, such exceptions have not been identified for the cod fishery and certainly not for the bycatch differences expected between the preferred alternative and the status quo. The economic effects of decreased catch in other fisheries are considered in the calculation of net benefits (item 8).

5. Expected Effects on Coastal Community Stability

The preferred alternative is not expected to result in a sufficiently large change in the distribution of catch by fishery or season to have a measurable effect on the stability of coastal communities. However, by fixing the allocation of cod between the trawl and non-trawl fisheries, the preferred alternative eliminates one source of uncertainty. This should be of some benefit with respect to community stability.

6. Historical Use of the Cod Fishery

As noted above, the preferred alternative will fix the distribution of cod between the trawl and non-trawl fisheries at about the average for the last few years.

7. Current Dependence on the Cod Fishery

Because the preferred alternative will fix the distribution of cod between the trawl and non-trawl fisheries at about the average for the last few years, the preferred alternative will tend to allow each cod fishery to maintain its current level of dependence.

8. Expected Effects on Economic Benefits to the Nation

Given that the preferred alternative is not expected to result in a significant change in the distribution of cod catch by fishery and given that the differences in the estimates of net benefits per mt of cod catch by fishery are not significantly different, the preferred alternative is expected principally to provide benefits as the result of increased stability and decreased uncertainty. The preferred alternative will also provide benefits by allowing a transfer of longline catch from the second to the third season. However, the latter benefit is expected to be quite small because the fixed gear fishery is expected to request and take most or perhaps all of its annual apportionment during the first season.

9. Expected Distribution Effects

The preferred alternative will maintain the recent distribution of catch between the trawl and non-trawl fisheries.

10. Expected Effects on Consumers

The preferred alternative is not expected to have an effect on domestic consumers with respect to the amount of food available or the price of that food because of (1) the relatively low importance of BSAI cod in the budgets of most households, (2) the availability of substitutes for BSAI cod, and (3) the minimal effect the preferred alternative is expected to have on the distribution of cod catch by fishery or season.

11. Expected Effects on Competitiveness of the U.S. Fishing Industry

The preferred alternative is expected to have too small of an effect on the distribution of catch to have a measurable effect the competitiveness of the U.S. fishing industry in domestic and world markets. However, by fixing the allocation of cod between the trawl and non-trawl fisheries, the preferred alternative eliminates one source of uncertainty. This should be of some benefit with respect to meeting business plans and being

competitive in international markets.

12. Expected Effects on Reporting, Management, Enforcement, and Information Costs

The preferred alternative is not expected to have an important effect on reporting, management, enforcement, and information costs. The annual determination of the season apportionments will require some time by the Council and NMFS. However, because the allocation of cod between trawl, longline and pot, and jig gear has been set, the process for apportioning the trawl fishery halibut PSC limit among trawl fisheries should be less contentious and less costly. There will be a small increase in the cost of monitoring the cod TAC and implementing closures because there will be separate quotas and closures by gear group. The net effect is expected to be a small increase in management costs.

13. Attainment of OY with Existing PSC Limits

The preferred alternative is not expected to have a significant effect on the ability of the groundfish fishery to take the 2.0 million mt OY approximately within the halibut PSC limits for the groundfish fishery.

14. Differences in the Quantity and Quality of Biological Data from the Cod Fisheries

The preferred alternative is not expected to change the quantity and quality of biological data from the cod fisheries.

15. Gear Conflicts and Vessel Safety

The preferred alternative is not expected to have a large enough effect on the distribution of catch by gear or season to affect gear conflicts or vessel safety.

16. Effects on Other Fisheries

The preferred alternative is not expected to have a large enough effect on the distribution of catch by gear or season to affect other fisheries significantly.

17. Fairness and Equity

The determination of what is fair is very subjective. The Council has often used the historical distribution of catch to define what is fair and has favored the traditional fishery. For example, the principal objective of the Inshore/Offshore allocation amendments was to prevent preemption of one group of participants by another. Alternatively, it can be argued that it is not fair to the Nation as a whole to have an allocation that does not maximize the benefits that the Nation can receive from its cod resources or from all resources into which cod is an input. These two definitions of what is fair often have different implications concerning what allocation is fair. The latter would include environmental benefits and costs to the extent they can be measured; therefore, it would include what some have referred to as being fair to the ecosystem. Because the rate and magnitude of change from the current distribution clearly affect adjustment costs, the historical distribution of catch is of importance in terms of both concepts of equity.

The differences by gear in estimated net benefits per mt of cod catch are not substantial enough to justify a change in the distribution of catch among gear groups. Therefore, the preferred alternative, that approximately maintains the current distribution, is equitable in terms of both standards of equity.

18. Options for Changing the Allocation of the Cod TAC Among Seasons Once the Initial Allocation Has Been Established

By limiting the framework authority to apportion seasonally its portion of the cod TAC to the longline and pot gear fishery, the preferred alternative makes the annual process much less contentious than if this authority also were created for trawl gear. However, it would have been even less contentious if the longline and pot gear apportionment had been split between longline and pot gear.

In summary, the preferred alternative meets the Council's objective to provide a measure of stability to the fishery while allowing various components of the industry to optimize their utilization of the resource. By doing this with only a minimal increase in management costs, the preferred alternative is expected to provide net benefits to the Nation.

1.7 Organization of the Document

Historical information is summarized in Chapter 2. Included are estimates of cod catch and biomass, data for the three cod fisheries, cod market information, and estimates of benefits per mt of cod catch by fishery and season. The data on which the summaries are based are presented in Appendices A-D. The BSAI groundfish fishery as a whole is not described in this document. The most recent description of the groundfish fishery as a whole is contained in the Economic Status of the Groundfish Fisheries off Alaska, 1992, an appendix to the Stock Assessment and Fishery Evaluation Document for Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1993. That document includes information on the catch and value of the fisheries, the numbers and sizes of fishing vessels and processing plants, and other economic variables that describe or affect the performance of the fisheries.

Chapter 3 contains summaries of Pacific cod biology and the biological analyses of the alternatives being considered. The latter is with respect to: (1) the effects on yield per recruit for Pacific cod; (2) the effects of fishing on spawning aggregations; (3) gear-specific effects on habitat and its productivity; (4) gear-specific and season-specific interactions with marine mammals and seabirds; and (5) biological effects of gear-specific and season-specific differences in bycatch rates. The summaries are based on information contained in Appendices E-I.

The economic analyses of the alternatives are contained in Chapter 4. Much of the analysis is based on the information presented in Chapters 2 and 3.

Chapters 5 through 9 address other specific requirements for a FMP amendment.

Information concerning the cod jig fishery and the 1993 cod fisheries are presented in an addendum to this public review draft.

As noted on the title page, Appendices A-I are under a separate cover. This was done to allow the reader to refer to information in an appendix more readily while reading the text contained in this volume.

2.0 PACIFIC COD CATCH AND THE PACIFIC COD FISHERIES

Pacific cod is taken as target catch in the cod fisheries and as bycatch in other groundfish fisheries. Although it is sometimes difficult to distinguish between cod catch in a multi-target fishery and cod bycatch in other fisheries, it is convenient to make such a distinction for some management and analytical purposes.

Cod catch data for the groundfish fisheries are summarized in Section 2.1. Section 2.2 summarizes information for the cod longline, pot, and trawl fisheries. Included are data on catch, discards, bycatch, processed products, and cod markets. Estimates of net economic benefits per mt of cod catch by fishery and season are also included. The summaries are based on the data presented in Appendices A - D.

The current definitions of target fisheries were used to identify the data associated with each of the three cod fisheries. Observations are defined in terms of a processor, week, area, and gear. If the estimate of retained cod catch is greater than that of any other potential target species for an observation, the data for that observation are by definition associated with the cod fishery of that specific gear. With one exception, the current definitions were also used to identify each of the other groundfish fisheries. The exception is that crab bycatch rate data were used to help differentiate between the mid-water and bottom trawl pollock fisheries in both 1991 and 1992. If the bycatch rate was greater than 0.5 crab per mt of groundfish, what would have otherwise been considered a mid-water trawl observation was recoded as a bottom trawl observation.

The PacFIN database is the source of the catch data reported for the foreign and joint venture fisheries for all years and for the domestic fisheries prior to 1990. The catch estimates for the 1990 domestic fisheries are based on Weekly Processor Report (WPR) data. Finally, blend estimates of catch are reported for the 1991 and 1992 domestic fisheries. The blend estimates of catch use WPR data or observer data for each processor and week based on the following rules. If the observer estimate of total catch of all TAC species is at least 10 percent greater than the WPR estimate or if the observer estimate is between 80% and 90% of the WPR estimate, only observer data are used for that processor that week. Otherwise, only WPR data are used for that processor that week.

There are two reasons blend estimates of catch are used when they are available. First, beginning in 1993, blend estimates will be used to monitor the attainment of TACs and PSC allowances. Second, for a fishery as a whole, the blend estimates are thought to be more accurate than either the observer or WPR estimates alone. The reasons that WPR estimates are no longer used alone to estimate catch include the following: (1) for at-sea processors, the WPR estimates are always dependent on product recovery rates and in many cases the recovery rates being used may understate actual catch; (2) products discarded or turned into meal, after first being processed and rejected for quality reasons, are often not accounted for correctly in estimating catch; (3) often discards are under estimated and/or under reported; and (4) under reporting of product weight can occur.

The blend estimates of total annual catch are substantially greater than the WPR estimates for most species. For Pacific cod, the 1991 WPR and blend estimates of total catch are 172,158 mt and 218,064 mt, respectively. The corresponding estimates for 1992 are 172,863 mt and 205,326 mt. Therefore, the blend estimates exceed the WPR estimate by 27 percent in 1991 and by 19 percent in 1992. The differences between the blend and WPR estimates and the availability of blend estimates of domestic fishery catch only for 1991 and 1992 result in an inconsistent data series, which tends to understate catch in the late 1980s and 1990 compared to catch in 1991 and 1992. However, because blend estimates were used for the foreign and joint venture fisheries, the estimates through the mid-1980s may be consistent with the estimates for 1991 and 1992. The catch data series for the domestic fishery is also inconsistent because the PacFIN estimates do not include discards. Therefore, the domestic fishery estimates for 1981-89 exclude discards but the estimates for 1990-92 include discards. This also tends to understate catch in the late 1980s compared to catch in the 1990s. All of the catch estimates for the joint venture and foreign fisheries include discards.

2.1 Cod Catch in the Groundfish Fisheries

The catch of Pacific cod in the BSAI groundfish fisheries has changed in several ways during the last 12 years. Each of several types of change is discussed below in a separate subsection.

2.1.1 Total catch, TAC, and biomass

Between 1981 and 1992, there were substantial increases in annual cod catch, the cod TAC, the percent of the TAC that was harvested, and catch as a percent of the biomass (Table A1). Catch increased from 62,395 mt in 1981 to 218,064 mt in 1991 and then decreased to 205,326 mt in 1992. The TAC increased from 78,700 mt in 1981 to 280,000 mt in 1987 and then decreased to 182,000 mt in 1992. The percent of the TAC harvested increased from 79.3 percent in 1981 to 113 percent in 1992 but was less than 57 percent in 1987. Catch as a percent of biomass increased from 6.2 percent in 1981 to 28.6 percent in 1992. Based on the catch estimates that are available, the full TAC was not harvested prior to 1991. However, if 1981-90 annual catches for the domestic fishery were adjusted both to account for the difference between WPR and blend estimates and to include discards, it is quite likely that the adjusted estimates would indicate that the cod TAC was taken fully or exceeded in 1988 and 1990.

The estimated biomass was relatively stable from 1981 through 1989 fluctuating between 1.0 million mt and 1.3 million mt. However, it declined to 0.9 million mt in 1990 and then to 0.7 million mt in 1992. The explanation of this recent decline and the expected future changes in biomass are discussed in Chapter 3.

2.1.2 Distribution of catch among the foreign, joint venture, and domestic groundfish fisheries

In addition to a large increase in total cod catch between 1981 and 1992, there was a complete change in which fisheries harvested the cod (Table A2). The percent of the total annual cod catch taken in the foreign fishery decreased from 63 percent in 1981 to 0 percent in 1988. The percent taken in the joint venture fishery increased from 15 percent in 1981 to 56 percent in 1988 and then decreased to 0 percent in 1991 with cod taken only as bycatch the previous year. The domestic fishery's share of the cod catch increased from 23 percent in 1981 to 95 percent in 1990 then to 100 percent in 1991 and 1992. This reallocation of cod from the foreign fishery to the joint venture fishery and then to the domestic fishery was the result of actions by the Council to fulfill one of the major objectives of the Magnuson Act.

2.1.3 Distribution of catch among gear groups

There were also substantial changes in the percent of the catch accounted for by each of three types of gear (Table A3). But unlike catch or the share of catch by fishery, there were not consistent trends in the shares of catch by gear. For the period as a whole, trawl gear was dominant. Annually, it accounted for between 44 percent and 99 percent of the total cod catch from 1981 through 1992. Longline gear accounted for between 1 percent and 49 percent of the annual catch for this period and pot gear accounted for 0 percent of the catch in the first 9 years and for 1 percent, 2 percent, and 7 percent, respectively, in 1990, 1991, and 1992. Due in part to the timing of the implementation of regulatory changes, the highest percent for longline gear (49 percent) and the lowest percent for trawl gear (44 percent) occurred in 1992.

For the domestic fishery alone, trawl gear was also dominant, but its dominance decreased rapidly beginning in 1989 (Table A4). Trawl gear accounted for 100 percent of the domestic fishery cod catch from 1981 through 1986, 97 percent in each of the next 2 years, but only 44 percent in 1992. The percent of the domestic fishery cod catch taken with longline gear increased from 0 percent in 1986 to 3 percent in 1987 and 1988 and then increased very rapidly reaching 49 percent for 1992.

For the 12-year period as a whole, the total joint venture and domestic (DAH) cod catch was about 1,438,000 mt and the cod catch in the domestic fishery alone (DAP) was about 1,044,000 mt. Approximately 81.3% of the DAH cod catch and 74.2 percent of the DAP cod catch were taken with trawl gear, 17.2% of the DAH

cod catch and 23.6 percent of the DAP cod catch were taken with longline gear, and only 1.6% of the DAH cod catch and 2.2 percent of the DAP cod catch were taken with pot gear.

The increase in the percent of catch taken with longline and pot gear was in part the result of cod trawl fishery closures beginning in 1989 due to halibut PSC limits being taken. The closures (Table A5) provided improved market and regulatory opportunities for the use of non-trawl gear. These opportunities increased participation in the cod fishery by vessels that had been designed to use longline or pot gear and by trawl vessels that were refitted to use fixed gear either just during trawl closures or during the entire fishing year.

The 1992 distribution of catch among the three gear groups probably was affected by the late implementation of the separate halibut PSC allowance for the cod trawl fishery and the delay in the implementation of the halibut PSC limit for the longline fishery. An estimate of the resulting effect on cod catch in each of the three cod fisheries is presented in Section 2.2.1.

2.1.4 Temporal distribution of catch

The distribution of cod catch among seasons has also changed substantially since 1981 (Table A6). The most pronounced change is the increase in the percent of catch that occurs in the first season (January- May) and the related decrease for the last season (September-December). In 1981 only 27 percent of the catch was in the first season and 45 percent was in the last season compared to 65 percent and 6 percent for the first and last seasons, respectively, in 1992. The percents taken in the first and last seasons in 1981 and 1992 bound the range for each of these two seasons. The percent of catch taken in the second season (June-August) ranged from a low of 13 percent in 1988 to a high of 37 percent in 1982 and was 27 percent in 1981 and 29 percent in 1992. The changes in the distribution of catch by season naturally reflect changes in the monthly distribution of total cod catch (Table A7).

During the last 3 years, the percent of the annual cod catch in the domestic trawl fisheries that was taken in the first season ranged from 78 percent to 85 percent (Table A8). The corresponding percent for the domestic longline fisheries increased annually from 28 percent in 1990 to 56 percent in 1992. For all domestic fisheries combined, it increased from 63 percent in 1990 to 65 percent in 1992.

There are principally three reasons for the redistribution of cod catch to the first season. First, it appears that from the perspective of the fishing operations, and perhaps from society's perspective as well, this is an optimal period to target on cod (see Section 2.2.13). Second, the use of the race for fish as the mechanism for allocating the TAC among competing fishermen provides individual fishing operations with an incentive to target on cod early in the year before the TAC is taken by others. Third, a number of actions taken by the Council have tended to increase catch during the first season. The Council actions include: (1) the prohibition on roe-stripping; (2) the establishment of the A and B seasons for BSAI pollock and quarterly apportionments of the GOA pollock TACs; (3) the delays of the flatfish fisheries in the BSAI and the rockfish fisheries in the GOA; (4) PSC limits for the trawl fisheries; and (5) the elimination of the BSAI Greenland turbot, sablefish, and arrowtooth flounder trawl fisheries in 1992. The "inshore/offshore" allocation of BSAI pollock and GOA pollock and cod is also expected to increase cod fishery effort during the first season. If approved by the Secretary of Commerce, exclusive registration between the BSAI or GOA pollock fisheries probably would also increase catch in the first season unless any such increase is prevented by the cod trawl fishery halibut PSC allowance for the first season. Together these three factors have increased both participation in the cod fisheries and the concentration of effort during the first part of the year.

2.1.5 Cod catch by domestic target fishery

Pacific cod is taken both in target fisheries and as bycatch in other groundfish fisheries. In the domestic fisheries, the percent of cod taken as catch and as bycatch has varied by month, year, and gear (Table A9). The percent of total cod catch in the domestic fishery accounted for by the cod trawl fishery declined from 52 percent in 1990 to 23 percent in 1992. The percent accounted for by other groundfish trawl fisheries

ranged from between 19 percent and 21 percent. The pollock bottom trawl fishery accounted for substantially more of the trawl cod bycatch than did any other trawl fishery (Table A10). For example in 1992, it accounted for 21.7 percent of the cod taken in the groundfish trawl fishery as a whole. The high cod bycatch in the bottom trawl pollock fishery was the result of a total catch of about 679,000 mt and a cod bycatch rate of about 3 percent. To the extent that cod and pollock are simultaneous target species for some fishing operations, the cod bycatch rate in the bottom trawl pollock fishery would be lower by an unknown amount if bottom trawl pollock operations were not interested in retaining cod. However, due to the tendency for cod and pollock to be found in the same areas, the decrease may be quite small. In 1992, the next largest amount was 9.5 percent, which was taken in the yellowfin sole fishery.

In all 3 years, the bycatch of cod in the other groundfish trawl fisheries probably was increased by the halibut PSC limit induced closures of the cod trawl fishery. Once those closures occurred, cod could only be taken as bycatch in other trawl fisheries. This probably gave some vessels an incentive to increase their bycatch of cod. With the current directed fishing standard for cod, cod bycatch can account for up to 20% of a vessel's retained catch once the cod fishery is closed. NMFS is planning an extensive review of all the directed fishing standards. That review is expected: (1) to result in new directed fishing standards that reduce the incentive to increase the bycatch of a species for which the target fishery is closed and (2) to provide a better understanding of what bycatch rates would be without such incentives.

Despite the progress that is expected to be made, categorizing fishing activity by target fishery will continue to be somewhat arbitrary for two reasons. First, in some instances there are multiple simultaneous target species. Second, during the weekly reporting period for each processor, the catch composition may be the product of several distinct target fisheries. The latter problem probably could be reduced by having processors that receive catch from catcher vessels report weekly catch by vessel and trip.

The 1990-92 cod bycatch rates in the other groundfish trawl fisheries varied by target fishery and year (Table A11). For the other trawl fisheries as a whole, the cod bycatch rates ranged from 2.1 percent in 1990 to 2.4 percent in 1992. Therefore, if for example the other trawl fisheries would be expected to catch 1.75 million mt of other groundfish, they would be expected to take from 36,750 mt to 42,000 mt of cod as bycatch.

The cod bycatch rates in the other longline fisheries as a whole ranged from 3.5 percent in 1992 to 6.8 percent in 1991. The comparable estimates for the pot fishery are 0 percent in 1991 and 1.8 percent in 1992. The importance of the volatility of the cod bycatch rates in the other longline and pot fisheries is reduced substantially because the levels of groundfish catch are very low for these fisheries. Cod catch in these other fixed gear fisheries accounted for less than 0.2 percent of the total cod catch in the domestic fishery between 1990 and 1992.

2.2 Cod Fisheries

The data discussed in this section are for the longline, pot, and trawl cod fisheries. Information concerning the cod jig fishery are presented in an addendum. Fishing activity for a week, area, gear, and processor and the associated effort, catch, bycatch, and fishery products are attributed to a cod fishery if cod is the dominant retained species. The trawl, longline, and pot cod fisheries can be compared in many ways. Each type of comparison is presented in a separate subsection.

2.2.1 Distribution of cod catch among the three cod fisheries

The estimates of cod catch in thousands of mt for each of the three cod fisheries and all other fisheries for 1990-92 (Tables A9 and A10) are as follows:

	Pacific Cod Fisheries			Other	Total
	Longline	Pot	Trawl	Fisheries	
1990	47.4	1.4	86.8	31.9	167.5
1991	79.6	6.7	90.1	41.7	218.1
1992	100.9	13.7	47.9	42.8	205.3
1992 adj	72.5	13.7	55.8	42.8	184.8.

The adjusted estimates for 1992 are explained below.

Given these catch estimates, the percent of total cod catch accounted for by each fishery each year is as follows:

	Pacific Cod Fisheries			Other	Total
	Longline	Pot	Trawl	Fisheries	
1990	28.3	0.8	51.8	19.0	100.0
1991	36.5	3.1	41.3	19.1	100.0
1992	49.1	6.7	23.3	20.8	100.0
1992 adj	39.2	7.4	30.2	23.2	100.0.

The 1990 estimates probably understate actual catch because they are based on WPR data not blend data. The effect on the percent taken in each fishery in 1990 will not be known until blend estimates are generated for 1990.

The 1992 distribution of cod catch among the three cod fisheries was thought to have been determined in part by the late implementation both of the separate halibut PSC allowance for the cod trawl fishery and of the halibut PSC limit for the longline fishery. The adjusted catch estimates for 1992 (1992 adj) are estimates of what the 1992 catches would have been: (1) if the full cod trawl fishery halibut PSC bycatch allowance of 2,359 mt had been available for the cod trawl fishery, (2) if the longline fishery had been closed once its 750 mt halibut bycatch mortality allowance had been taken, and (3) if the blend estimates of catch had been used to estimate when the cod TAC and each of these two PSC allowances were taken.

The adjusted 1992 cod catch estimates by fishery were derived from cumulative weekly cod catch and halibut bycatch data (Table A12). These data indicate that the cod longline fishery would have been closed July 12 because the groundfish longline fishery halibut PSC limit of 750 mt of bycatch mortality (or 4,688 mt of bycatch with a discard mortality rate of 16 percent) was exceeded the week ending July 12. As of that date, cod catch in the cod longline fishery totaled about 72,500 mt and halibut bycatch in the groundfish longline fisheries was 4,991 mt.

The cod trawl fishery was actually closed May 6 because some of the 2,359 mt halibut PSC allowance had been used in the pollock fishery. As of that May 6, the cod catch and halibut bycatch in the cod trawl fishery were about 47,500 mt and 1,787 mt, respectively. Had the cod trawl fishery been allowed to continue and had its cod catch per week and halibut bycatch per week continued at 4,128 mt and 293 mt, respectively, (the average catch and bycatch rates for the last two weeks of the cod trawl fishery in 1992), the cod trawl fishery would have been closed by May 24 for exceeding its halibut PSC allowance of 2,359 mt. As of that date, its cod catch and halibut bycatch, respectively, would have been about 55,800 mt and 2,373 mt.

Given that these would have been the cod trawl and cod longline closures and cod catches, the total cod catch as of July 12 would have been about 167,200 mt. This consists of 55,800 mt for the cod trawl fishery, 72,500 mt for the cod longline fishery, 8,300 mt for the cod pot fishery, and 30,600 mt as bycatch principally in other groundfish trawl fisheries.

After July 12, cod would have continued to be taken as catch in the cod pot fishery and as bycatch in other fisheries. If the pot fishery would have continued as it actually did and taken about 13,700 mt of cod by the week ending September 20, and if the other groundfish fisheries had continued as they actually did, they would have taken about 42,800 mt of cod as bycatch by the end of 1992 and the total cod catch would have been 184,800 mt.

These estimates of the adjusted catch for 1992 are based on the discard mortality rate that was used to monitor halibut bycatch mortality for the longline fishery during 1992. The use of the higher discard mortality rate that the IPHC has used to adjust the 1993 halibut fishery quotas for halibut bycatch in the cod longline fishery would have reduced the adjusted catch in the cod longline fishery. Because the 1992 halibut PSC allowances for the trawl fisheries were in terms of bycatch not bycatch mortality, the adjusted catch estimate for the cod trawl fishery is not dependent on the discard mortality rate.

The 1992 adjusted estimates are intended to approximate the effects of the timely implementation both of the PSC limits and of blend estimates. Due to the many operational and regulatory interdependencies among the groundfish fisheries, precise estimates of the effects are not feasible.

As noted above, the changes with respect to the distribution of cod catch among the three cod fisheries between 1990 and 1992 are explained in part by halibut PSC limits for the trawl fisheries and the resulting cod trawl fishery closures in 1990-92.

2.2.2 Catch for at-sea versus onshore processing

Among the three domestic cod fisheries, the percent of catch taken for onshore processing was substantially lower for the longline fishery than for either the pot or trawl fishery (Table A13). For 1990 through 1992, the percent of cod catch for onshore processing ranged from about 1 percent to 2 percent with the longline fishery, compared to 13 percent to 29 percent with the pot fishery, and 21 percent to 34 percent with the trawl fishery.

2.2.3 Groundfish species mix

Among the three cod fisheries, there are significant differences in the species mix of their groundfish catch (Table A14). For 1990 through 1992, cod accounted for 58 percent to 64 percent of the groundfish taken in the cod trawl fishery. The corresponding figures are, 85 percent to 93 percent for the cod longline fishery and 95 percent to 98 percent in the cod pot fishery. Much of the other groundfish catch in the cod trawl fishery was pollock, it accounted for 19 percent to 27 percent of the total catch in the cod trawl fishery.

The species mix can also be compared in terms of FOB Alaska product values. With the exception of the cod trawl fishery, other groundfish species are not a significant part of the total value of the cod fisheries (Table A15). For 1990 through 1992, other groundfish species accounted for from 9.3 percent to 10.5 percent of the value of the processed products from the cod trawl fishery. The corresponding estimates are 1.9 percent to 3.6 percent for the cod longline fishery and 0.2 percent to 1.1 percent for the cod pot fishery.

2.2.4 Discards of cod and other groundfish

For 1990-92, approximately 98 percent to 100 percent of the annual cod catch in the cod longline fishery was retained (Table A16). The retention of cod was about the same for the cod pot fishery, it ranged from 97 percent to 100 percent. Cod retention was lower in the trawl fishery, it ranged from 93 percent in 1992 to 97 percent in 1991. The difference between the fisheries with the lowest and highest retention rates varied from 1 percentage point in 1991 to 6 percentage points in 1992. The use of blend estimates of total and retained catch for 1991 and 1992, as opposed to WPR data for 1990, probably results in better estimates of retention rates.

The percent of the catch of other groundfish that was retained was much lower for each of the three cod fisheries. It ranged from 10 percent to 21 percent in the cod longline fishery, from 4% to 12% in the cod pot fishery, and from 15 percent to 18 percent in the cod trawl fishery.

2.2.5 Cod product mix

The product mixes differ substantially between the cod trawl fishery and the other two cod fisheries for 1990-92 (Table A17). Cod taken with longline or pot gear is used principally to produce headed and gutted (H&G) cod. For example, H&G cod accounted for between 93 percent and 96 percent of the product weight of cod in the cod longline fishery and for between 78 percent and 84 percent of the product weight of cod in the cod pot fishery. H&G cod accounted for only between 29 percent and 41 percent of the product weight of cod in the cod trawl fishery. Fillets, which accounted for from 0 percent to 2 percent of the cod product weight in the cod longline and for from 2 percent to 6 percent in the pot fisheries, accounted for from 19 percent to 31 percent of the cod product weight in the cod trawl fishery. Both whole fish and salted and split cod accounted for larger shares of the cod product weight in the cod trawl fishery than in the other two cod fisheries.

2.2.6 Prohibited species bycatch and bycatch mortality

Prohibited species bycatch and bycatch mortality in the cod fisheries and the other groundfish fisheries have received substantial attention for many years. Estimates of both were generated using bycatch and bycatch mortality rate data from the Observer Program and groundfish catch data from the Weekly Processor Reports and Observer Program. Because, the blend catch estimates that are used to estimate bycatch for 1991 and 1992 have not been published previously, they are presented in Table A18. Estimates of 1990-92 prohibited species bycatch and bycatch mortality, respectively, by species, gear, target fishery, and year are contained in Tables A19 and A20. The associated bycatch and bycatch mortality rates are in Tables A21 and A22. The discard mortality rates used to estimate bycatch mortality for 1990-92 are listed in Table 2.1.

Table 2.1 Estimated discard mortality rates by fishery and species used for 1990-92. (percentage %)

Halibut

Pot 5% Longline 20%	
Trawl	
Mid-water pollock	80%
Atka mackerel, rock sole, yellowfin sole, and other flatfish	70%
Pacific cod, rockfish, and bottom pollock	60%
Sablefish, turbot, and arrowtooth flounder	40%

Red king crab

Trawl 80% Pot 37% Longline 37%

Tanner crab (C. bairdi)

Trawl 80% Pot 30% Longline 45%

Salmon and Herring All gear 100%.

The basis of each of the discard mortality rate estimates is discussed in Appendices B and C.

For 1990-92, bycatch mortality rates for the three cod fisheries varied substantially among bycatch species, fisheries, seasons, and years. The seasons are as follows: (1) January-May, (2) June-August, and (3) September-December. The bycatch mortality data are discussed below by bycatch species.

2.2.6.1 Halibut bycatch mortality

The halibut bycatch mortality rate is defined as halibut bycatch mortality as a percent of groundfish catch. Estimates of halibut bycatch mortality rates for each of the three cod fisheries and seasons during 1990-1992 are contained in Table A23. Due to the halibut PSC limit induced trawl closures, the trawl fishery did not have sufficient catch and effort beyond the first season to provide useful estimates. Therefore, the estimates for the cod trawl fishery during the second and third seasons should be ignored and the estimates for the first season should be considered the annual estimates as well. The cod pot fishery estimates for the first season of 1990 and 1991 also should be ignored because they are based on too little catch and effort to be meaningful.

In the cod longline fishery, the annual halibut bycatch mortality rates ranged from 0.68 percent in 1990 to 1.33 percent in 1992. The halibut bycatch mortality rates in the cod longline fishery differed consistently and substantially by season. The rates were lowest in the first season and highest in the second season. Although the third season rates were substantially lower than the second season rates, they were more than twice the rates of the first season. In 1992, the cod longline fishery accounted for almost 29 percent of the estimated total halibut bycatch mortality in the groundfish fishery.

The annual halibut bycatch mortality rates were substantially lower in the cod pot fishery than in the other two cod fisheries. They ranged from 0.04 percent in 1992 to 0.07 percent in 1990. For the two seasons that can be compared for all 3 years for the cod pot fishery, halibut bycatch mortality rates do not exhibit a consistent seasonal pattern. The rate was lower in the second season than in the third season in 1990

and 1992 but it was higher in the second season in 1991. In 1992, the only year with adequate catch in each season for a comparison, the second season had the lowest rate. The lack of a consistent pattern probably is explained in part by the fact that this is a new and changing fishery. In 1992, the cod pot fishery accounted for about 0.1 percent of the estimated total halibut bycatch mortality in the groundfish fishery.

For the reasons noted above, seasonal comparisons are not possible for the cod trawl fishery. In 1990 and 1992 , the annual halibut bycatch mortality rates in the cod trawl fishery were approximately equal to the rates in the cod longline fishery. However, in 1991 the rate was about 42 percent higher in the cod trawl fishery. In 1992, the cod trawl fishery accounted for just under 20 percent of the estimated total halibut bycatch mortality in the groundfish fishery.

2.2.6.2 Herring bycatch mortality

The herring bycatch mortality rate is defined as herring bycatch mortality as a percent of groundfish catch. The herring bycatch mortality rate was approximately 0 in the cod longline and pot fisheries (Table A24). It was about 0.01 percent in the 1991 and 1992 cod trawl fisheries. The cod trawl fishery accounted for less than 0.6 percent of the total herring bycatch in the groundfish fisheries.

2.2.6.3 Crab bycatch mortality

Management measures to control the bycatch of crab in the groundfish fisheries have been focused principally on Tanner crab (C. Bairdi) and red king crab. Therefore, the following summary is limited to these two species. Crab bycatch mortality rates are defined in terms of crab per mt of groundfish catch.

Tanner Crab (C. Bairdi)

For 1990-92, the season bycatch rates for Tanner crab in the cod longline fishery were, with two exceptions, less than 0.07 (Table A25). In 1992 the rates for the second and third seasons were 0.1 and 0.3, respectively. The average annual rates ranged from 0.01 in 1990 to 0.09 in 1992. In 1992 the cod longline fishery accounted for less than 0.3 percent of the estimated total Tanner crab bycatch mortality in the groundfish fishery.

Tanner crab bycatch mortality rates were substantially higher in the cod pot fishery than in the longline fishery. The annual rate increased from 4.2 in 1990 to 5.1 in 1992. By year, the season with the highest rate was as follows: 2nd in 1990, 3rd in 1991, and 2nd again in 1992. In 1992 the cod pot fishery accounted for only 2.6 percent of the estimated total Tanner crab bycatch mortality in the groundfish fishery.

Tanner crab bycatch mortality rates in the trawl cod fishery were between those in the two fixed gear fisheries. The annual rate ranged from 1.9 to 3.3. In 1992, the cod trawl fishery accounted for 4.5 percent of the estimated total Tanner crab bycatch mortality in the groundfish fishery.

Red King Crab

For 1990-92, the seasonal bycatch rates for red king crab in the cod longline fishery were, with one exception, less than 0.003 (Table A25). In 1992 the rate for the second season was 0.022. The average annual rate ranged from 0.000 in 1990 to 0.009 in 1992. In 1992 the cod longline fishery accounted for less than 1 percent of the estimated total red king crab bycatch mortality in the groundfish fishery.

Red king crab bycatch mortality rates were substantially higher in the cod pot fishery than in the longline fishery each year. The annual rate decreased from 2.55 in 1990 to 0.27 in 1992. In 1990 and 1991, the highest rate was for the third season. The second season has the highest rate in 1992. The cod pot fishery accounted for 2.2 percent of the estimated total red king crab bycatch mortality in the 1992 groundfish fishery.

Red king crab bycatch mortality rates in the trawl cod fishery usually were between those in the two fixed gear fisheries. The annual rate ranged from 0.002 in 1992 to 0.112 in 1990. In 1992, the cod trawl fishery accounted for less than 0.2 percent of the estimated total red king crab bycatch mortality in the groundfish fishery.

2.2.6.4 Salmon bycatch mortality

Salmon bycatch mortality rates are defined in terms of salmon per mt of groundfish catch. Because the Council has placed specific emphasis on the bycatch of chinook salmon, this summary addresses chinook salmon and all other salmon separately.

Chinook Salmon

The annual chinook salmon bycatch rates have been extremely low in the cod longline fishery. For 1990-92, they ranged from 0.0001 in 1990 to 0.0006 in 1991 (Table A26). The rates are sufficiently low that differences in seasonal rates are not important. The total bycatch in 1992 was 49 salmon.

The observer data indicate that no chinook salmon were taken as bycatch in the cod pot fishery. The chinook bycatch rate in the cod trawl fishery increased from 0.024 in 1990 to 0.061 in 1992 and the total bycatch in 1992 was 4,942 salmon. The cod trawl fishery accounted for 11.7 percent of the estimated total chinook salmon bycatch mortality in the 1992 BSAI groundfish fishery.

Other Salmon

There was no measurable bycatch of other salmon in the cod pot fishery and the bycatch rates were very low in the other two cod fisheries. The annual rates ranged from 0.0004 to 0.0010 and from 0.004 to 0.008, respectively for the longline and trawl fisheries. The rates are sufficiently low that differences in seasonal rates are not important. In 1992, the three cod fisheries combined accounted for only 0.4 percent of the other salmon bycatch mortality for the groundfish fishery as a whole.

2.2.7 Relative importance of the cod fisheries

During the last 3 years, the cod fishery has accounted for a substantially larger share of the catch in the groundfish longline and pot fisheries than in the groundfish trawl fishery (Table A27). For the BSAI groundfish longline fishery and excluding halibut, the cod fishery accounted from 88 percent to 97 percent of the groundfish catch. Each year, the cod fishery accounted for approximately 100 percent of the BSAI groundfish catch with pots. However, the cod fishery accounted for only between 4 percent and 8 percent of the annual BSAI groundfish trawl catch. The importance of the cod fishery for the pot vessels is overstated substantially because the crab fisheries, not other groundfish fisheries, are the principal fisheries for many of the pot vessels.

The relative importance of the cod fishery to the BSAI groundfish longline and trawl fisheries can also be measured in terms of the share of product value generated in the cod fishery. For the BSAI groundfish longline fishery and excluding halibut, the cod fishery accounted from 82 percent to 91 percent of its FOB Alaska value. The comparable estimates for the BSAI trawl fishery are 5 percent to

13 percent.

Because not all the vessels that participate in the other groundfish fisheries participate in the cod fisheries, the relative importance of the cod fisheries to the vessels that participate in them can be measured more meaningfully in terms of the percent either of Alaska groundfish fishing weeks or of Alaska groundfish product value associated with the cod fisheries. Such information is summarized in Tables A28 and A29 for the factory trawlers and factory longliners that participated in the cod fisheries. Similar information is summarized in Tables A30 and A31 for the shoreside delivery trawlers and longliners that participated in the cod fisheries. Factory pot vessels and shoreside delivery pot vessels were not included in these comparisons because the crab fisheries, not other groundfish fisheries, are the principal other fisheries of these vessels.

The information in Tables A28 and A29 is based on annual data by catcher/processor. For the two tables, the data by vessel were sorted in ascending order, respectively, by the percent of Alaska groundfish weeks that were cod weeks and the percent of Alaska groundfish product value that was from the cod fishery. Table A28 reports the following by vessel (1) the cumulative number of vessels, (2) the cumulative percent of vessels, (3) the number of BSAI cod fishery weeks, (4) the number of Alaska groundfish weeks, (5) BSAI cod weeks as a percent of Alaska groundfish weeks, (6) the cumulative number of BSAI cod fishery weeks, (7) the cumulative number of Alaska groundfish weeks, and (8) cumulative BSAI cod weeks as a percent of cumulative Alaska groundfish weeks. The cumulative data are for all vessels up to that point in the table. The number of cod weeks for a vessel is the number of unique weeks it was determined to have participated in the BSAI cod fishery based on weekly blend estimates of retained catch, weekly processor reports, and the definition of cod as a target fishery. The number of Alaska groundfish weeks for a vessel is the number of unique weeks it participated in the Alaska groundfish fishery. For Table A29, information on the number of weeks is replaced with information on product value (FOB Alaska) and items 3, 4, 6, and 7 are not reported.

The data in Table A28 indicate the following with respect to dependence in terms of weeks of operation.

1. For the roughly 50 percent of cod fishery factory longliners with the lowest dependence on the cod fishery, about 53 percent, 57 percent, and 44 percent of their Alaska groundfish weeks were spent in the BSAI cod longline fishery, respectively, in 1990-92. The corresponding estimates for cod factory trawlers that participated in the cod trawl fishery are 11, 8, and 5 percent.

2. For cod factory longliners the percent of Alaska groundfish weeks in the BSAI cod longline fishery ranged from 4 percent to 100 percent, 3 percent to 100 percent, and 3 percent to 100 percent, respectively, in 1990-92. The comparable estimates for cod factory trawlers are 3 percent to 100 percent, 2 percent to 100 percent, and 2 percent to 38 percent.

3 The cod factory longliners that spent from 75 percent to 100 percent of their Alaska groundfish weeks in the BSAI cod longline fishery were 56 percent, 73 percent, and 56 percent, respectively, in 1990-92. The comparable estimates for cod factory trawlers are 5 percent, 4 percent, and 0 percent.

4. For the cod factory longline fleet as a whole, the percent of Alaska groundfish weeks accounted for by the BSAI cod longline fishery were as follows for 1990-92: 70 percent, 75 percent, and 70 percent. The comparable estimates for cod factory trawlers are 27 percent, 16 percent, and 13 percent.

The data in Table A29 indicate the following with respect to dependence in terms of processed product value in the groundfish fisheries.

1. For the roughly 50 percent of cod fishery factory longliners with the lowest dependence on the BSAI cod fishery, about 56 percent, 37 percent, and 29 percent of their Alaska groundfish product value was from the BSAI cod longline fishery, respectively, in 1990-92. The corresponding estimates for factory trawlers that participated in the BSAI cod trawl fishery are 6 percent, 3 percent, and 2 percent.

2. For cod factory longliners the percent of Alaska groundfish product value from the cod longline fishery ranged from 4 percent to 100 percent, 0 percent to 100 percent, and 0% to 100 percent, respectively, in 1990-92. The comparable estimates for factory trawlers are 0 percent to 100 percent, 0 percent to 99 percent, and 0 percent to 29 percent.

3. The percent of cod factory longliners that received from 75 percent to 100 percent of their Alaska groundfish product value in the BSAI cod longline fishery were 59 percent, 70 percent, and 56 percent in 1990-92. The comparable estimates for factory trawlers are 5 percent, 6 percent, and 0 percent.

4. For the cod factory longline fleet as a whole, the percent of Alaska groundfish product value accounted for by the BSAI cod longline fishery were as follows for 1990-92: 80 percent, 67 percent, and 61 percent. The comparable estimates for cod factory trawlers are 18 percent, 7 percent, and 8 percent.

In summary, the cod factory longline fleet as a whole is much more dependent on the BSAI cod fishery in terms of either weeks of operation or product value than is the cod factory trawler fleet. However, within each fleet there are vessels that are highly dependent on the BSAI cod fishery and there are other vessels that have a very low level of dependence on the BSAI cod fishery.

The dependence of a fleet on the cod fishery is determined in part by the definition of a cod fishery and any ambiguity there is concerning the actual target fishery. This typically is more of a problem for the multi-target trawl fisheries. Although the extent of the problem is not known, the groundfish bycatch rates for the cod trawl fishery suggest that cod usually is a distinct target and that the current definitions generally are adequate.

Comparable data are presented in Tables A30 and A31 for catcher boats that participated in the cod longline and trawl fisheries. Although the cumulative data in the tables are for all vessels, the length of each table was reduced by including the individual vessel observations only for the first and last vessel and the vessels at approximately each 5 percent break point for the cumulative percent of vessels. Theses data indicate the following.

1. For the cod catcher boat longline fleet as a whole, the percent of Alaska groundfish weeks value accounted for by the BSAI cod fishery was 33 percent in 1991 and 34 percent in 1992. The comparable estimates for cod catcher boats are 31 percent and 21 percent.

2. For the cod catcher boat longline fleet as a whole, the percent of Alaska groundfish exvessel value accounted for by the BSAI cod fishery was 21 percent in 1991 and 29 percent in 1992. The comparable estimates for cod catcher boats were 18 percent and 7 percent.

3. In 1992, the cod longline catcher boat fleet as a whole was more dependent on the BSAI cod fishery in terms of weeks of operation and much more dependent in terms of exvessel value than

was the cod trawl catcher boat fleet. However, within each fleet there are vessels that are highly dependent on the BSAI cod fishery and there are other vessels that have a very low level of dependence on the BSAI cod fishery.

2.2.8 Effort and capacity in the cod fisheries

The level of effort in the cod fisheries can be measured in terms of: (1) the number of vessels and vessel weeks; (2) the number of vessel weeks combined with information on vessel size; and (3) output. The number of catcher/processors in the cod fisheries increased from 72 in 1990 to 102 in 1992 (Table A32). The number of catcher/processors that only used trawl gear decreased from 40 to 32, but because the number that used a combination of gear including trawl increased from 0 to 13, the total number using trawl gear increased from 40 to 45. The numbers of catcher/processors in the cod longline and pot fisheries, respectively, increased from 27 to 54 and from 5 to 19. The number of longline catcher processors that used only longline gear increased from 27 to 41 and the number using only pot gear increased from 5 to 15. The number and percent of catcher/processors in two or more cod fisheries increased from 0 in 1990 to 14 and 14 percent in 1992. Of the 14 combination vessels in 1992, the numbers with each gear combination were as follows: trawl and longline 10; trawl and pot 1; trawl, longline, and pot 2; and longline and pot 1. Part of the increase in the number of vessels participating in the cod fishery with fixed gear or both trawl and fixed gear is explained by the halibut PSC limits which closed the cod trawl fishery well before the cod TAC was taken in 1990 through 1992. The possibility of halibut PSC limit induced closure of the cod longline fishery in the future probably will increase the numbers of catcher/processors that participate in the cod fishery with pot gear alone and with other gear in combination with pots. The gear that a vessel uses during a given period is, of course, limited by the gear closures that are in place.

In 1992 the average overall lengths of catcher/processors were 135 ft, 160 ft, and 173 ft, respectively, in the cod longline, pot, and trawl fisheries (Table A32). The corresponding average lengths in 1990 were 127 ft, 163 ft, and 170 ft. Therefore, the average length increased the most for longline catcher/processors and decreased for pot catcher/processors. In terms of mean vessel lengths, the catcher/processors in the cod fisheries that use only trawl gear are the largest (188 ft in 1992). The comparable average sizes for those that were used only in the longline or pot fishery were, respectively, 132 ft and 163 ft. The trawlers that also use longline or pot gear are smaller than those that use only trawl gear. This probably is explained by the fact that it is less economically feasible to add longline gear to a larger factory trawler.

The total number of factory longliner fishing weeks increased from 603 in 1990, to 836 in 1991, and to 1,073 in 1992 (Table A28). The corresponding number of factory trawler weeks were 382, 288, and 195. The information in Table A28, including the definition of fishing weeks, was explained in Section 2.2.7. The number of cod longliner catcher boat weeks in the BSAI cod fishery decreased from 267 in 1991 to 197 in 1992 (Table A30). The number of cod trawler catcher boat weeks in the BSAI cod fishery decreased from 341 in 1991 to 252 in 1992.

The harvesting capacity of each of the three cod fisheries as measured in terms of maximum cod catch per month has changed substantially between 1990 and 1992 (Table A9). For the cod longline fishery, maximum cod catch per month increased annually and rapidly from about 7,100 mt in 1990 to 9,700 mt, and 17,400 mt, respectively, in 1991 and 1992. The maximum cod catch per month in the cod pot fishery increased from 630 mt in 1990 to 2,100 mt in 1991 and 4,300 mt in 1992. For the cod trawl fishery, maximum cod catch per month was 19,900 mt, 43,100 mt, and 23,000 mt, respectively, in 1990-92.

2.2.9 Cod Product Prices

Several sources of cod fishery product prices were used. The Economic Appendix to the BSAI SAFE document contains monthly cod product prices that are reproduced in Table A33. NMFS Fisheries Market News Report is the source of the U.S. prices and Monthly Statistics of Agriculture Forestry and Fisheries is the source of the Japanese prices reported in that table. The latter includes prices reported in Yen per kilogram. Those prices were converted to Dollars per pound using monthly exchange rates. Weekly FOB Seattle prices for cod and pollock fillets for January 1991 - December 1992 are in Table A34. Urner Barry Seafood Price Current is the source of that data. Japanese Ishinomaki Auction prices of trawl and longline H&G medium size cod for November 1990 - July 1992 are reported in Table A35. The Seafood Price Current prices and the Japanese auction prices were used to estimate the average cod H&G prices and both cod and pollock fillet prices for 1991 and 1992. Because longer time series were available for the NMFS Fisheries Market News Report prices, they were used to analyze the historical relationship between H&G and fillet cod prices.

The prices of frozen cod landed in Japan in Yen per kg were converted to FOB Alaska prices using monthly Dollar to Yen exchange rates, by converting from kg to pounds, and by subtracting the costs that account for the difference between the landed price in Japan and the FOB Alaska price. The FOB Seattle cod fillet prices were converted to FOB Alaska prices by subtracting $0.10 per pound. The resulting price series are shown in Figure 2.1. Because most of the product associated with the landed price of frozen cod is H&G product, this price series is used as a proxy for Japanese H&G prices.

Three different method were used to compare the relationships between these two price series. The first was a simple comparison of both the ranges of the absolute values of the two price series and the range of the fillet prices relative to the H&G prices. During the period of January 1987 through July 1992, fillet prices had a maximum price of $2.71 per pound in February 1991, a minimum price of $1.76 per pound in November 1989, and an average price of $2.22. The H&G prices ranged from $1.13 per pound in November 1991 to $0.36 in September 1989 and had an average of $0.68 per pound. The monthly ratio of the fillet price to the H&G price ranged from a high of 5.26:1 in September 1989 to 1.98:1 in February 1990. The ratio expressed as a percent is depicted in Figure 2.2.

The second method was a comparison of the relative volatility of the two price series in terms of beta which is used as a measure of the relative volatility of stock exchange prices. Beta is the slope coefficient in the regression of the periodic percentage change in one price on the periodic percentage change in another price series. With the monthly percentage change in H&G prices regressed on the monthly percentage change in fillet prices, the beta coefficient is 0.43. This beta value indicates that, for this period as a whole, H&G prices were less volatile than fillet prices.

The third method of comparison was to determine the extent to which fillet prices could be explained by H&G prices. Using the ordinary least squares procedure to regress fillet prices on H&G prices resulted in residuals that were clearly not random with respect to time. Therefore, the regression was run using the Cochrane-Orcutt procedure to account for the serial correlation of the residuals. The results of that regression demonstrates a very strong relationship between H&G and fillet prices. Approximately 95% of the variability in fillet prices was explained by the regression. The fitted and actual fillet prices are depicted in Figure 2.3 and the summary statistics for the regression are presented in Table A36.

In early 1993, there were dramatic decreases in many whitefish prices in Japan, Europe, and North America. Included was a dramatic reduction in the price of H&G cod both in absolute terms and relative to the price of cod fillets. Since then, there appears to have been a substantial recovery in the price of longline H&G cod and a smaller recovery in the price of trawl caught H&G cod.

There have been several responses to the price decreases. The European Community (EC) has imposed minimum prices for cod and some other groundfish, diplomatic actions are underway to reduce the supply of cod from Russian waters, and some producers are switching from H&G products to fillets. The minimum prices set by the EC will tend to decrease the European demand for lower quality cod H&G products to the extent that EC buyers would have to pay the same price for both low and higher quality H&G products. A decrease in the supply of cod from Russian waters is expected to increase the relative price of H&G cod because much of that cod was landed as H&G products. Finally, the switch to fillet products will also tend to increase the price of H&G cod relative to fillets. The increased ability of pollock to compete with cod in some fillet markets will also tend to increase the price of H&G cod relative to fillets. The analysis of the relationship between H&G and fillet prices also indicates that the difference that existed between H&G and fillet prices in the first 2 months of 1993 will not be sustained.

There are several reasons why cod prices over the next several years will tend to be below those of 1991 and 1992. The recovery of Northern European cod stocks will increase world supply. Russia has economic incentives to have relatively high exploitation rates and to export an increased percent of its catch. Pollock has become a better substitute for cod than it had been.

2.2.10 U.S. Cod Exports

Data on U.S. cod exports from Alaska, Oregon, and Washington combined by product form and country of destination are summarized in this section. Whole and dressed cod account for the vast majority of cod exports in terms of both product weight and value. Fillets account for a small percent of the exports (Table A37). For example, during the first 11 months of 1992, of the 128.6 million lbs of cod exports, whole and dressed cod accounted for 124.3 million lbs and fillets accounted for only 2.8 million lbs and of the $99.4 million of exports $93.7 million were whole or dressed cod and $2.5 million were fillets. These data coincide with information from the industry that indicate that most H&G products are exported and that most fillets are consumed domestically.

In 1989 Japan accounted for 89 percent of the exports of whole and dressed cod by value but by 1992 it accounted for only 55 percent despite a substantial increase in exports to Japan. Dramatic growth in exports to the Republic of Korea, Norway, and Portugal explain most of the decrease in the dominance of exports to Japan. Portugal has been the dominant country for U.S. exports of salted cod. It took over 96 percent of the salted cod exports in 1989, 1990, and 1992 but only 77 percent of the 1991 exports. If the dramatic increase in 1991 salted cod exports to Japan is due to a product classification error, the 1991 dominance of Japan for whole and dressed cod and that of Portugal for salted cod are understated.

2.2.11 Catch, effort, and bycatch rate data from the foreign cod longline fishery and the joint venture cod trawl fishery

Observer data for the foreign cod longline fishery and the joint venture cod trawl fishery are presented to augment the data available for the domestic cod fisheries. There are several reasons why this may be useful. First, observer data are not available for the domestic fisheries prior to 1990. Second, because the domestic longline fishery is a relatively new and rapidly changing fishery, the recent performance of this fishery is less indicative of its future performance. Third, due to the halibut PSC limit induced closures of the cod trawl fishery in 1990-92, very limited information is available concerning the performance of that fishery beyond the first season. However, it is recognized that changes in the

regulatory, economic, and biological environments limit the extent to which the domestic fisheries did or will reflect the performance of the foreign or joint venture cod fishery.

Foreign Cod Longline Fishery

Table A38 provides seasonal and annual estimates of cod catch, cod catch as a percent of groundfish catch, halibut bycatch rates, cod catch per hook, and cod catch per hachi for the foreign cod longline fishery. A distinction was made between cod and other groundfish longline fisheries based on fishing depth. If the depth for an observation was less than 400 m, that observation was included in the cod fishery.

In most years, cod catch was concentrated in the first and third seasons. Cod catch as a percent of groundfish catch was usually highest the first season, but its ranking between the second and third seasons varied by year.

In 4 of the 7 years, the halibut bycatch rate was highest in the first season. For the other three years, it was highest in the second season. For the 7-year period as a whole, the weighted average bycatch rate was 2.00 percent, 2.14 percent, and 2.02 percent, respectively for the first, second, and third seasons. The annual bycatch rate ranged from 1.03 percent to 2.67 percent and averaged 2.02 percent.

Cod catch per hook (kg/hook) was highest is the second season only for the last two years. For the seven-year period as a whole, the weighted average catch per hook was 1.45 kg, 0.97 kg, and 0.96 kg, respectively for the first, second, and third seasons. The annual rate varied from 0.65 to 1.25 kg per hook and averaged 1.08 kg per hook.

Cod catch per hachi (mt/hachi) was highest in the first season in 5 years and lowest in the second season for 5 years with ties for the highest and lowest in several years. For the seven-year period as a whole, the catch weighted average catch per hachi was the same in the second and third seasons and about 50 percent higher in the first season. The annual rate varied between 0.02 and 0.05 mt per hachi and averaged 0.04 mt per hachi. A "hachi" is 70 to 100 meters of longline gear.

Joint Venture Cod Trawl Fishery

Table A39 provides seasonal and annual data for the joint venture cod trawl fishery from 1981 through 1989. The data include estimates of cod catch, cod catch as a percent of groundfish catch, bycatch rates for several prohibited species, cod catch per haul, and cod catch per hour of trawling. Cod fishery observations were defined by haul. If cod accounted for at least 60 percent of the groundfish in a haul, it was included as a cod fishery observation.

With two exceptions, catch was concentrated in the first season. A larger than normal percent of the annual catch was taken the second season in 1982, 1983, 1987. The most substantial catches for the third season were in 1988 and 1989. Cod as a percent of groundfish catch in that fishery was consistently highest in the first season and usually lowest in the third season.

There is not a readily discernable seasonal pattern in halibut bycatch rates. In 1988, the year with the most substantial third season catch, the bycatch rate was lowest in the second season and highest in the third. The rate in the first season was about twice that of the second and the rate in the third season was almost twice that of the first season.

Herring bycatch rates were typically very low. Red king crab bycatch rates were highly variable. The three occurrences of exceptionally high rates were in the third season. Tanner crab bycatch rates were typically highest the first season and lowest the second. With one exception, the chinook salmon bycatch rates were less than 0.005 salmon per mt of groundfish. For the first season of 1982, the rate was 0.02.

The rate for other salmon was always less than 0.005.

Catch per trawl hour was generally highest in the first season and lowest in the third, but often there were small or no differences between seasons. The catch per haul data reported in Table A39 are incorrect.

2.2.12 Monthly wave height and wind speed information

The relative merits of fishing for cod during different seasons is determined in part by wave height and wind speed. Tables A40 - A42 contain information by month and area on mean wave height, mean wind speed, percent of wave height greater than 4 meters and 6 meters, and percent of wind greater than 28 knots and 41 knots.

2.2.13 Estimates of Net Benefits per Metric Ton of Cod Catch

Cod harvests in the cod trawl, longline and pot fisheries of the BSAI are three alternative uses for cod, each of which results in the production (output) of valuable food products from both cod and from the other groundfish species harvested as bycatch in the cod fisheries. Each use of cod also requires the use of a variety of inputs that are of value to society. In addition to cod, the inputs used in these fisheries include: groundfish and prohibited species bycatch; fishing vessels, gear, and bait used in harvesting; the plant, equipment and materials used for processing; and the fuel and labor used throughout the production process. Each cod fishery uses a different combination of these inputs to produce a different combination of cod and other groundfish products.

The difference between the values of the outputs (revenues) and inputs (costs) for a particular use provides a measure of the net benefit of that use. Revenues are generated from sales of cod and other groundfish products and costs include the value of the inputs used to produce the fishery products. Net benefits provides a means of comparing alternative uses of cod because the sum of net benefits under various scenarios about harvest distribution among cod fisheries or across seasons provides an estimate of the overall net benefit of the cod fishery.

It is a measure that attempts to account for many of the differences among the three cod fisheries and seasons that were discussed above. Therefore, it provides a method of summarizing the overall effects of those differences. This aggregate measure addresses gear-specific and season-specific differences in species mix, retention, product mix, product prices and value, costs for groundfish and prohibited species taken as bycatch, product recovery rates, and harvesting and processing costs.

The annual and seasonal estimates of net benefits per mt of cod catch for each of three cod fisheries for 1991 and 1992 were based on estimates of the following for each fishery:

1. Gross revenue per mt of cod catch (AGR) based on groundfish products and FOB Alaska prices,

2. Harvesting and processing costs per mt of cod catch (AHPC) paid by the owners of harvesting and processing operations, and

3. The opportunity cost of groundfish TAC species and prohibited species bycatch per metric ton of cod catch (AOCB), where groundfish bycatch is the catch of groundfish other than cod.

The estimates of the average value of outputs (AGR) and the two parts of the average value of inputs (AHPC and AOCB) are used as follows to calculate the net benefit per ton of cod catch (ANB) for each

cod fishery, season, and year:

ANB = AGR - AHPC - AOCB.

These estimates use data from both blend catch data set and the WPR product weight data set, therefore, BSAI cod fishery observations were excluded if both blend data and product weight data were not available. Observations for which product weight exceeded catch weight were also excluded. To eliminate the possibility that different subareas were reported in the blend data and WPR data, cod weeks were defined by processor and gear for the BSAI as a whole, not by subarea. The methods used to estimate AGR, AHPC, and AOCB for each cod fishery are discussed in Appendix D.

The estimates of net benefits per mt of cod catch are intended to provide useful but not complete information concerning net benefits per mt ton of cod catch by fishery and season for 1991 and 1992. They provide incomplete information for the following reasons.

1. Because neither the Council nor NMFS has established the ongoing data collection programs required to measure historical net benefits, the parameter values of the harvesting and processing cost model are based on data for a very small number of operations.

2. The allocation of some costs to a cod fishery is problematical for harvesting or processing operations that participate in multiple fisheries. Although there is no theoretically correct way to allocate such costs, there are some circumstances under which these costs should not be ignored.

3. Two components of the harvesting and processing costs that are particularly difficult to estimate were not included in the estimates of either average harvesting and processing cost or average net benefit. The excluded costs are the opportunity cost of using harvesting and processing capacity and the cost of replacing it.

4. The estimates of net benefits do not attempt to capture all the benefits and costs of each use. For example, the effects both on habitat and on the long term productivity of the BSAI cod stocks are not included. However, such effects are discussed in Chapter 3.

5. Neither benefits nor costs are considered beyond primary processing.

6. The assumption of constant average input and output values is a gross simplification.

7. Estimates of net benefits per mt of cod catch provide a basis for partial equilibrium analysis but not for general equilibrium analysis of the alternatives. The difference between the two is that the former considers only changes in the value of inputs and outputs of the cod fisheries but the latter also considers the resulting effects on other fisheries and other sectors of the economy that would result, for example, from the redeployment of fishing effort in the cod fishery to other fisheries. The development of a general equilibrium model for the fisheries was not possible given the time and resources that were available to evaluate the alternatives being considered. However, many of the effects that are not captured by the partial equilibrium model, that is used, are addressed separately.

The usefulness of even accurate estimates of historical net benefits is reduced substantially by the variability in the factors that jointly determine net benefits per mt of cod catch.

The small number of weekly observations both for the cod trawl fishery in the second and third seasons

of 1991 and 1992 and for the cod pot fishery in the first season of 1991 are not included in the estimates of net benefits per mt of cod catch because the samples were too small to provide meaningful estimates. Blend estimates of 1991 and 1992 cod total catch and retained catch by fishery for all seasons are presented in Table 2.2. These estimates provide a measure of the sample size for each season.

Table 2.2 BSAI blend estimates of total cod catch (mt) and the percent (%) retained by fishery and season, 1991-92.

	Longline		Pot		Trawl	
	Total	Ret.	Total	Ret.	Total	Ret.
1991						
Jan-May	30,385	90%	53	100%	138,558	63%
Jun-Aug	24,915	85%	2,687	96%	854	46%
Sep-Dec	32,159	84%	2,702	92%	.	.
1992						
Jan-May	63,431	86%	3,450	96%	71,136	62%
Jun-Aug	43,672	84%	8,432	95%	6	100%
Sep-Dec	7,512	79%	531	94%	.	.

Source: NMFS Alaska Region blend estimates.

The presentation of the estimates of average net benefits and its three components is followed by a discussion of the potential effects of the limitations listed above.

2.2.13.1 Estimates of gross revenue per metric ton of cod catch (AGR)

With the exception of H&G cod, annual prices were used to estimate the FOB Alaska value of catch in the three cod fisheries. For H&G cod, a base annual price was adjusted seasonally. The seasonal adjusters were: 0.90 for January-April, 0.75 for May-August, 0.85 for September-October, and 1.0 for November-December. Because, these seasons do not coincide with the seasons being used, monthly prices were used. The base annual prices were \$0.86 per pound for the longline and pot fisheries and \$0.73 per pound for the trawl fishery. For each season, the price equals the product of the base price and the seasonal adjuster. The prices that were used are presented and explains more fully in Appendix D.

The same prices were used to calculate gross revenue per mt of cod catch for 1991 and 1992. Therefore, any difference in the estimates for 1991 and 1992 are due to differences in the species composition of catch, retention rates, product mix, product recovery rates, and the monthly distribution of catch.

The annual AGR estimates for 1991 are \$784, \$710, and \$1,194, respectively, for the cod longline, pot, and trawl fisheries (Table A43). The corresponding estimates for 1992 are \$749, \$765, and \$1,139. The cod trawl fishery had the highest estimate both years because it produces a larger percent of the higher valued fillets (Table A17).

The seasonal pattern of the AGR estimates for the longline fishery was not the same in 1991 and 1992 and is not what was expected given the seasonal price adjustments used for H&G cod. Everything else being constant, the seasonal price adjustments described above would result in the highest AGR in the third season and the lowest AGR in the second season. In 1991, the first season had the highest AGR and the third season had the lowest. In 1992, the highest AGR was again in the first season and, as

expected, the lowest was in the second season. The unexpected results are explained principally by the apparent difference in total groundfish product weight per mt of cod catch (Appendix D, Table D3). For the 1991 cod longline fishery, it decreased from 0.530 in the first season to 0.523 the second season and to 0.437 in the third season. In 1992, it decreased from 0.475 in the first season to 0.450 the second season and to 0.437 the third season. The change in the value of this variable can be explained either by seasonal differences in retention rates and product recovery rates or by seasonal differences in the relative accuracy of the estimates of catch and product weights. With only two years of data, it is difficult to determine if there is a seasonal pattern in this variable or simply a random error in the estimates of catch and product weights.

For the 1991 cod pot fishery, AGR was, as expected, lower the second season than the third season and there was not sufficient data for the first season to estimate AGR. For the 1992 pot fishery, AGR was highest the first season and, as expected, lowest the second. The highest AGR occurred in the first season because a substantially higher percent of eastern cut H&G cod that season compared to the third season (Appendix D, Table D3).

Due to the halibut PSC allowance induced closures of the cod trawl fisheries in 1991 and 1992, estimates of AGR are only available for the first season.

Within each fishery there were substantial differences in the estimates among individual operations (Table A44). For example, in 1992 the range of AGR estimates by fishery were $539 to $4,564 for the cod longline fishery, $256 to $2,336 for the cod pot fishery, and $266 to $3,417 for the cod trawl fishery. Within each fishery, these ranges reflect differences in retention rates, product recovery rates, product mixes, species mixes, and the monthly distribution of catch. This is because, for a given fishery, species, product form, and season, the same price was used for each operation. Therefore, these ranges do not capture the additional variability among operations that results from differences in prices. Industry representatives have indicated that, for a given gear, species, product form, and month, there can be substantial differences in the FOB Alaska prices received by different processors. The reasons for this include differences in size, quality, marketing effort, the combination of species and product forms being sold by the processor, and timing.

The high end of the range for each fishery suggests that there may be some errors in the weekly processor report data or the blend catch data or that there are inconsistencies between these two data sets. The data are being reviewed to eliminate such problems if they exist.

2.2.13.2 Estimates of harvesting and processing cost per metric ton of cod catch (AHPC)

Three variable cost models were used for each of the following types of harvesting and processing operations: factory longliner, factory pot vessels, fillet factory trawler, and H&G factory trawler. The three models for each type of operation were intended to capture some of the variability that exists among individual operation within each type of operation.

Each of the three cost models for the factory longliners is based on information for a different vessel. For each of the other types of catcher/processors, all three models are based on information for a single vessel. For these operations, the first and third models are the second model with the time dependent variable cost decreased by 25 percent and increased by 25 percent, respectively. The resulting ranges of variable cost estimates are substantially larger for these operations than for the factory longliners. The specifics of the variable cost models are discussed in Appendix D.

The ranges of estimates of annual variable cost per mt of cod catch are as follows:

	1991	1992	1991-92
Longline	$473-$558	$463-$546	$467-$551
Pot	$342-$430	$441-$591	$408-$538
Trawl fillet	$588-$735	$553-$690	$571-$712
Trawl H&G	$462-$598	$416-$547	$446-$580
Trawl all	$530-$672	$510-$645	$521-$660.

These estimates, combined with the estimates of the minimum and maximum variable cost per mt of cod catch for individual operations (Table A46), indicate that there are probably substantial overlaps in variable cost per mt of cod among most of the types of operations.

For the 1991 cod longline fishery, variable cost per mt of cod catch (AVC) was lowest the first season for two of the three cost models and highest the third season for two models. For 1992, AVC increased each semester with each of the cost models.

For the pot fishery, AVC was higher the third season than the second season for each model both years. In 1992, the only year with adequate data during the first season, the lowest AVC was the first season for each of the cost models.

There was not sufficient catch and effort in the trawl fishery in the second and third seasons to provide meaningful estimates.

Although they were not used to estimate net benefits per mt of cod catch, estimates were also made of annual overhead costs. Overhead costs include the following categories of costs: accounting, legal, associations, marketing, administrative/office, insurance, port fees, and permits. Overhead costs per mt of cod catch was estimated three different ways for each type of operation. It was estimated based on estimates of overhead costs per fishing week, per pound of processed product, and per dollar of product value (Table A47). The overhead cost models are described in Appendix D.

As noted above, when a harvesting or processing operation participates in multiple fisheries, there is no theoretically correct way to allocate such costs, but under some circumstances they should not be ignored. The estimates of overhead costs were not used to estimate net benefits per mt of cod catch. The reasons for excluding average overhead costs are (1) the theoretical problem of allocating such costs to cod fisheries, (2) the ranking of the different types of operations in terms of overhead costs varied for the three methods of allocating overhead cost, (3) there was substantial overlap of estimates among the different types of operations, (4) overhead costs probably vary more among individual operation in a particular category than they do among categories, and (5) if the alternatives being considered would not affect entry or exit for the fishing industry as a whole, overhead costs would not be affected and, therefore, they should not be considered in evaluating the alternatives.

The estimates of variable cost per unit of cod catch that are used to estimate net benefits per mt of catch are based on (1) 1991 and 1992 cod fishery performance data for all catcher/processors, (2) cost models, and (3) gear-specific FOB Alaska prices by species and product form. The estimates of variable cost per mt of cod catch by fishery, year, and season were then used as estimates of the variable cost per mt of cod catch for the catcher boat-shore based harvesting and processing operations. All other components of the estimates of net benefits were based on cod fishery performance data for all harvesting and processing operations. Given the dominance of at-sea processing in all three cod fisheries, the absence of separate cost models for shorebased processing cannot introduce a significant bias unless the costs are substantially different for fish processed on shore. In 1992, the percent of cod catch taken for onshore processing was 1 percent in the cod longline fishery, 29 percent in the cod pot fishery, and 21% in the cod trawl fishery.

2.2.13.3 Estimates of the opportunity cost of prohibited species and groundfish bycatch per metric ton of cod catch (AOCB)

This section summarizes the estimates of the bycatch cost of halibut, other prohibited species, and groundfish other than cod. The methods used to estimate bycatch costs are described in Appendix D.

Halibut

Two sets of estimates of halibut bycatch costs in the cod fishery were made. The lower estimates account for only the immediate and automatic reduction in the halibut fishery quota that results from estimated halibut bycatch mortality in the groundfish fishery. The higher estimates also account for subsequent adjustments to halibut quotas that will occur over time due to the effects of bycatch mortality on the exploitable biomass for halibut. That is, the higher estimates include the halibut fishery yield loss due to both the immediate and certain adjustment and additional losses that are less immediate and less certain.

The lower estimates are expected to understate the actual catch foregone in the halibut fishery because they use less information and do not account for subsequent adjustments to halibut fishery quotas. The higher estimates attempt to account for both the immediate and subsequent adjustments to halibut fishery quotas. If the estimates of the subsequent adjustments are better approximations of what the actual adjustments will be than are the estimates that there will be no subsequent adjustments, the higher estimates are clearly better.

The lower estimates for halibut are comparable to assuming that the bycatch effects for the other prohibited species are zero. This is because they are both based on the assumption that, subsequent to the immediate quota adjustment that is zero for the other prohibited species, no adjustment will be made.

The immediate adjustment is a 1 mt reduction in the halibut fishery quota for each 1 mt of halibut bycatch mortality in the groundfish fishery. The additional yield loss is a function of the size of the halibut taken as bycatch. Therefore, because the size composition of halibut bycatch varies among the three fisheries, the estimates of yield loss per mt of halibut bycatch mortality differ by fishery. The estimates of the discounted yield loss per mt of halibut bycatch mortality are 1.09 mt, 1.05 mt, and 1.69 mt, respectively, for the cod longline, pot, and trawl fisheries (Appendix D, Table D7). The estimates were developed by the International Pacific Halibut Commission. The discounted yield loss is used to account for the fact that the yield loss occurs over many years. The estimates reported above are with a discount rate of 7 percent. Table D7 also include estimates for discount rates of 0 percent, 5 percent, and 9 percent.

The use of fishery-specific estimates of the yield loss to the halibut fishery per mt of bycatch mortality in the groundfish fishery is the latest step in a logical progression to address the problem of bycatch measured in terms of reduced benefits from the halibut fishery. The first step was the recognition that it is bycatch mortality, not bycatch, that affects halibut fishery yield loss. The latest step is the recognition that future yield loss depends on both the level of bycatch mortality and the size distribution of the halibut subject to that mortality. The next logical steps may be to estimate yield loss by time and area for each fishery and to establish and monitor halibut PSC limits in terms of yield loss instead of in terms of bycatch mortality.

Lower Halibut Estimates Based Only on the Immediate Adjustment to Halibut Fishery Quotas

For 1991, the lower estimates of halibut bycatch cost per mt of cod catch are approximately $11, $0.6, and $25, respectively, for the cod longline, pot, and trawl fisheries (Table A48). The corresponding estimates for 1992 are $20, $0.5, and $29. Each year the estimate was lowest for the pot fishery and

highest for the trawl fishery. For the lower halibut bycatch estimates, there is one reason why the halibut bycatch cost is substantially higher for the trawl fishery than for the longline fishery for 1992, even though the halibut bycatch mortality rates were about the same. The halibut bycatch mortality rate for a fishery is halibut bycatch mortality as a percent of the total groundfish catch of that fishery and cod is a smaller percent of the total groundfish catch in the cod trawl fishery than in the cod longline fishery. Therefore, even when they have the same bycatch mortality rate, the trawl fishery will result in more halibut bycatch mortality per mt of cod catch.

Each year for the longline fishery, the halibut bycatch cost was substantially lower the first season than in the second or third season and highest in the second season. The cost in the pot fishery did not have a consistent seasonal pattern for the 2 years. In 1991, the second season had the higher cost but it 1992 it had the lowest cost. For the reasons stated above, inter-seasonal comparisons are not possible for the trawl fishery.

High Halibut Estimates Based on the Immediate and Subsequent Adjustments to the Halibut Fishery Quotas

For 1991, the higher estimates of halibut bycatch cost per mt of cod catch are approximately $12, $0.6, and $42, respectively, for the cod longline, pot, and trawl fisheries. The corresponding estimates for 1992 are $22, $0.6, and $50. The difference between the estimates for the trawl fishery and the other two fisheries are greater for the higher estimates. This is because these estimates account for yield loss that depends on the size composition of the bycatch and that yield loss is greater for the cod trawl fishery which on average takes smaller halibut as bycatch. The higher and lower estimates have the same seasonality because the estimates of yield loss per mt of halibut bycatch were made by fishery but not also by season.

In addition to the differences in halibut bycatch costs by fishery, year, and season, there were substantial differences among individual operations for any given fishery, year, and season (Table A49). For example, the range of estimates of the higher halibut bycatch cost per mt of cod catch for the 1991 were $3.6 to $128 for the cod longline fishery, $0.1 to $2.6 for the pot fishery, and $0 to $449 for the trawl fishery. The corresponding estimates for 1992 are $5.1 to $99, $0.1 to $1.4, and $0 to $217.

Herring

The herring bycatch cost per mt of cod catch was $0.00 in both the longline and pot cod fisheries and was $0.01 and $0.09 for the trawl cod fishery in 1991 and 1992, respectively (Table A50).

Tanner Crab (C. bairdi)

For 1991, the estimates of Tanner crab bycatch cost per mt of cod catch are $0.03, $1.39, and $2.57, respectively for the cod longline, pot, and trawl fisheries. The corresponding estimates for 1992 are $0.05, $1.32, and $1.57.

Red King Crab

For 1991, the estimates of red king crab bycatch cost per mt of cod catch are $0.00, $1.47, and $0.31, respectively for the cod longline, pot, and trawl fisheries. The corresponding estimates for 1992 are $0.09, $0.14, and $0.11.

Chinook Salmon

For 1991, the estimates of chinook salmon bycatch cost per mt of cod catch are $0.02, $0.00, and $1.98, respectively for the cod longline, pot, and trawl fisheries. The corresponding estimates for 1992 are $0.01, $0.00, and $2.45.

Herring, Tanner Crab, Red King Crab, and Chinook Salmon Combined

For 1991, the estimates of the bycatch cost per mt of cod catch for herring, Tanner crab, red king crab, and chinook salmon combined are approximately $0.05, $2.86, and $4.86, respectively for the cod longline, pot, and trawl fisheries. The corresponding estimates for 1992 are $0.15, $1.47, and $4.22.

The cost for the longline fleet is low enough that its seasonality does not matter. For the pot fishery, the seasonal patterns are not the same in 1991 and 1992. For 1991, the cost was lower the second season, but for 1992, it was highest the same season.

Groundfish Excluding Cod

The following procedure was used to estimate the opportunity cost of groundfish bycatch per metric ton of cod catch. The gross FOB Alaska value per mt of catch for each groundfish species, other than cod, was calculated by estimating the FOB Alaska value of the products of that species that were retained in all non-cod BSAI groundfish fisheries and then dividing that value by the estimate of the total catch of that species in those fisheries. The opportunity cost of each species was then calculated by taking 38% of the estimated product value per mt because the variable cost was estimated to be 62% of the FOB Alaska values. This variable cost estimate is based on cost and value data collected for the analysis of Amendment 18, the Inshore/Offshore allocation. The estimate of the opportunity cost of bycatch by species was multiplied by the blend estimate of bycatch by species and the sum of the opportunity costs across species was divided by the blend estimate of cod catch. It was assumed that: (1) all groundfish bycatch was subject to 100% mortality whether or not it was retained and (2) groundfish taken as bycatch in a cod fishery would have otherwise been taken in other groundfish fisheries. This process and its results are explained in Appendix D.

In both 1991 and 1992, the bycatch cost of groundfish per mt of cod catch was substantially higher in the cod trawl fishery than in the other two cod fisheries and the cost was lowest in the pot fishery. The 1991 estimates are $23, $1, and $140, respectively, for the longline, pot, and trawl cod fisheries (Table A51). The corresponding estimates for 1992 are $16, $3, and $136. The cost of bycatch is offset partially in each cod fishery when it is retained and contributes to the product value of that cod fishery.

For the longline cod fishery in both 1991 and 1992, this cost was lowest the first season and substantially higher the third season. For the pot fishery, the cost was very low each season.

The estimates of groundfish bycatch cost by year, cod fishery, and species (Table A51.1) provide the information necessary to adjust the estimates of groundfish bycatch cost per mt of cod catch for alternative assumptions concerning whether the bycatch of a specific species otherwise would have been harvested in other groundfish fisheries. For example, the 1991 estimates of $141 for the cod trawl fishery and $23 for the cod longline fishery both include $1 for arrowtooth flounder. If the arrowtooth flounder bycatch in the cod fishery did not reduce arrowtooth flounder catch in other fisheries, the estimates for the cod trawl and longline fisheries should be reduced by $1.

There was substantial variability in the cost of groundfish bycatch among individual operations in each cod fishery (Table A52). For some fisheries, years, and seasons, the estimates of the maximum groundfish bycatch cost per mt of cod catch for an individual operations suggest that there are data errors. The data are being reviewed and any necessary corrections will be made to Table A52.

2.2.13.4 Estimates of net benefits per metric ton of cod catch (ANB)

The estimates of net benefits per mt of catch provide an aggregate measure that summarizes the joint effects of differences in product value, variable harvesting and processing cost, prohibited species bycatch cost, and groundfish bycatch cost all per mt of cod catch. Because there were three sets of variable cost estimates and two sets of prohibited species bycatch cost estimates, there are six sets of net benefit estimates. The estimates of net benefits and its components are summarized by year, season, fishery, cost model, and prohibited species cost estimate in Table 2.3. The estimates are also depicted in Figures 2.4 - 2.7.

The estimates with the higher prohibited species bycatch costs indicate the following with respect to net benefit per mt of cod catch (ANB).

1. The trawl fishery generally had the highest annual ANB. The only overlap was between the highest cost model for the trawl fishery and the lowest cost model for the pot fishery.

2. Annual ANB is generally lower in the longline fishery than in the pot fishery but there is some overlap between these two fisheries.

3. For the pot fishery, ANB was marginally higher in the second season than in the third season in 1991, but in 1992, ANB decreased substantially from the first to second season and then to the third season.

4. For the longline fishery, ANBs were substantially larger in the first seasons in both 1991 and 1992 than in the other seasons and benefits were typically higher in the second season than in the third, but often not substantially.

5. For the cod longline fishery, each 1,000 mt of cod that is transferred from the first season to the third would decrease net benefits by $188,000 or by $228,000 based on 1991 and 1992 data. This unexpected result is explained by the following: a decrease in the ratio of product weight to catch weight between the first and third seasons in both years (Table D3); the increase in variable cost between the first and third seasons both years (Table 1); and in 1992 a decrease in the average price of the principal products between the first and third seasons (Table D2) due to the concentration of third season catch during September.

6. For each 1,000 mt of catch that is taken from the first season trawl fishery and given to the first season longline fishery, net benefits would be reduced by $85,000 or by $100,000 based on 1991 and 1992 data.

7. For each 1,000 mt of catch that is taken from the first season trawl fishery and given to the third season longline fishery, net benefits would be reduced by $273,000 or by $328,000 based on 1991 and 1992 data.

8. Conclusions 2 and 3 would not be changed substantially even if it is assumed that halibut bycatch mortality will be eliminated in the cod longline fishery.

9. For each 1,000 mt of catch that is taken from the first season trawl fishery and given to the first season pot fishery, net benefits would be increased by $212,000 based on 1992 data. In 1991, there was not sufficient catch in the pot fishery the first season to allow a meaningful comparison.

These summary statements also apply to the estimates which include the lower halibut bycatch cost estimates. However, with the lower prohibited species cost estimates, the overlap between the annual estimates of ANB for the pot and trawl fisheries is eliminated.

There was substantial variability in the estimates of net benefit per ton of cod catch among individual operations in each cod fishery (Table A53).

2.2.13.5 Qualifications concerning the estimates of average net benefits (ANB)

These estimates of average net benefits capture many of the effects of both gear-specific and season-specific differences with respect to (1) the effects of prohibited species bycatch mortality, (2) species selectivity and discard rates for other groundfish, (3) product quality and value, and (4) harvesting and processing costs excluding external costs. However, they do not capture benefits beyond primary processing. Therefore, from the perspective of the Nation, the benefits per mt of cod catch will tend to be understated for the trawl fishery because the trawl fishery produces a larger proportion of products for domestic markets. There are two reasons why this bias is expected to be small. First, there are substitutes for cod from the Alaska trawl fishery, such as cod from other Alaska fisheries, Alaska pollock, cod and other species from non-Alaska fisheries, and non-fish protein. Therefore, the net benefit of trawl caught cod, in terms of producer surplus beyond the primary processing level, is the difference between the surplus with that cod and the surplus with the best substitute for it. Second, cod exports allow for imports that result in producer surplus associated with adding value to the imports.

Consumer surplus is ignored for all products. All else being equal, the U.S. consumer surplus that is ignored will be greater for the cod trawl fishery than for the cod longline or pot fishery because a larger percent of the cod products from the trawl fishery are consumed domestically. However, this bias is expected to be quite small for the same reasons that ignoring producer surplus beyond primary processing is not expected to introduce a significant error.

An upward bias is introduced in the estimates of prohibited species bycatch costs to the extent that the decrease in catch in the crab, halibut, herring, and salmon fisheries increases the prices of the products of these fisheries. If the price is sufficiently responsive to the decrease in supply, the net value of the products of these fisheries would actually increase. Although prices are not expected to be that responsive, some price response is expected.

Both the opportunity cost of using a vessel or plant and the cost of replacing vessels, plants, and equipment were exclude from the estimates of average harvesting and processing cost and average net benefits. The direction of the bias introduced by these omissions is not known. The same is true for the omitted annual overhead costs for the circumstances in which they should be considered.

The estimates of net benefits per ton of cod catch are functions of many variables including product prices. In early 1993, there was a dramatic reduction in the price of H&G cod both in absolute terms and relative to the price of cod fillets. Since then, there appears to have been a substantial recovery in the price of longline H&G cod and a smaller recovery in the price of trawl caught H&G cod. Once it is clearer what both absolute and relative product prices will be, revised estimates of benefit per ton of cod catch should be made using the 1991 and 1992 performance data and 1993 prices.

Table 2.3 Estimates of net benefit per mt of cod catch (ANB) and its components by fishery, variable cost model, and season, 1991-92.

Cod Longline Fishery

	1991 Jan-May	1991 Jun-Aug	1991 Sep-Dec	1992 Jan-May	1992 Jun-Aug	1992 Sep-Dec	1991 Jan-Dec	1992 Jan-Dec
Gross	845	784	722	777	704	772	784	749
Var. cost mod1	476	471	473	445	474	556	473	463
Var. cost mod2	509	548	552	483	560	676	535	524
Var. cost mod3	546	562	566	515	571	678	558	546
Lo proh cost	5	15	15	9	35	23	11	20
Hi proh cost	5	16	16	10	39	25	12	22
Gf. cost	11	40	21	11	21	27	23	16
ANB mod1 w/lo	354	258	213	311	173	166	277	250
ANB mod2 w/lo	321	181	134	273	88	46	215	190
ANB mod3 w/lo	284	167	120	242	77	43	193	168
ANB mod1 w/hi	354	257	212	310	170	164	276	249
ANB mod2 w/hi	321	179	133	272	84	44	214	188
ANB mod3 w/hi	283	165	119	241	73	41	192	166

Table 2.3 Continued.

Cod Pot Fishery

	1991 Jan-May	1991 Jun-Aug	1991 Sep-Dec	1992 Jan-May	1992 Jun-Aug	1992 Sep-Dec	1991 Jan-Dec	1992 Jan-Dec
Gross	.	671	749	1,017	658	768	710	765
Var. cost mod1	.	295	386	377	438	748	340	434
Var. cost mod2	.	336	432	431	513	907	384	507
Var. cost mod3	.	378	479	485	588	1,067	428	579
Lo proh cost	.	1	0	1	0	1	1	1
Hi proh cost	.	2	5	2	2	2	3	2
Gf. cost	.	1	1	1	4	4	1	3
ANB mod1 w/lo	.	374	362	639	216	16	368	327
ANB mod2 w/lo	.	333	315	585	141	-143	324	255
ANB mod3 w/lo	.	291	269	531	66	-303	280	182
ANB mod1 w/hi	.	373	357	638	215	15	365	326
ANB mod2 w/hi	.	332	311	584	140	-144	321	253
ANB mod3 w/hi	.	290	264	529	65	-304	277	180

Cod Trawl Fishery

	1991 Jan-May	1991 Jun-Aug	1991 Sep-Dec	1992 Jan-May	1992 Jun-Aug	1992 Sep-Dec	1991 Jan-Dec	1992 Jan-Dec
Gross	1,194	.	.	1,139	.	.	1,194	1,139
Var. cost mod1	530	.	.	510	.	.	530	510
Var. cost mod2	601	.	.	577	.	.	601	577
Var. cost mod3	672	.	.	645	.	.	672	645
Lo proh cost	25	.	.	29	.	.	25	29
Hi proh cost	47	.	.	54	.	.	47	54
Gf. cost	140	.	.	136	.	.	140	136
ANB mod1 w/lo	499	.	.	464	.	.	499	464
ANB mod2 w/lo	428	.	.	397	.	.	428	397
ANB mod3 w/lo	357	.	.	329	.	.	357	329
ANB mod1 w/hi	477	.	.	440	.	.	477	440
ANB mod2 w/hi	406	.	.	372	.	.	406	372
ANB mod3 w/hi	335	.	.	305	.	.	335	305

Note: All figures are dollars per mt of cod catch. ANB w/lo and ANB w/hi, respectively, are estimates of ANB with the lower and higher estimates of the bycatch cost of prohibited species per mt of cod catch. There was not sufficient catch in the trawl fishery the second and third seasons of 1991 and 1992 or in the pot fishery the first season of 1991 to provide meaningful estimates of ANB.

3.0 PACIFIC COD BIOLOGY AND BIOLOGICAL ANALYSES OF THE ALTERNATIVES

3.1 Pacific Cod Biology

3.1.1 Introduction

Pacific cod (*Gadus macrocephalus*) is distributed widely over the eastern Bering Sea (EBS) continental shelf and slope as well as in the Aleutian Islands region. Since tagging studies have demonstrated inter-area movement, the resource in the two areas is managed as a single unit. However, most assessment research has focused on the EBS portion of the stock. The most recent stock assessment is included in the Stock Assessment and Fishery Evaluation Document for Groundfish Resources of the Bering Sea/Aleutian Islands Regions as Projected for 1993. A brief summary of Pacific cod chapter of that document is presented below.

3.1.2 Biological Parameters

Pacific cod begin recruiting to the commercial fishery around age 3. The oldest cod aged to date at the Alaska Fisheries Science Center was 18 years old. The instantaneous rate of natural mortality is estimated at a value of 0.35 (this value, which is slightly higher than the estimate of 0.29 used in the SAFE report, gives the best fit to the data in the latest Synthesis model). For the past several years, assessments of this stock have used a maturity schedule indicating a length at 50 percent maturity close to 61 cm (about 6 years). However, concern has recently arisen regarding the accuracy of this schedule. To bracket the range of likely results, an alternate schedule with a length at 50 percent maturity close to 48 cm (about 4 years) is also used to compute target fishing mortality rates and yield per recruit in Section 3.2. Pacific cod can reach lengths in excess of 100 cm, and weights in excess of 15 kg.

3.1.3 Estimates of Abundance

Estimates of total abundance from Alaska Fisheries Science Center demersal trawl surveys on the EBS shelf since 1979 are shown in Table 3.1. Survey results indicate that biomass increased steadily from 1979 through 1981, then remained relatively constant from 1981 through 1989. The first significant decrease in biomass was observed in 1990, when the biomass estimate dropped by 26 percent. 1990 was the first year since 1983 in which the 95 percent confidence interval for the biomass estimate did not overlap the confidence interval from the preceding year. The same was nearly true for 1991, when the biomass estimate dropped by another 25 percent. The downward trend seems to have leveled off in 1992, with the point estimate coming in 3 percent higher than the 1991 value.

In terms of numbers (as opposed to biomass), the record high was observed in 1979, when the population was estimated to include over 1.5 billion fish. Numerical abundance declined by 29 percent in 1980 and 27 percent in 1981. Between 1981 and 1986, numerical abundance fluctuated within a range of 580-850 million fish. From 1986 to 1989, numerical abundance decreased at an average rate of 26 percent per year. In 1990, the trend reversed, with numerical abundance increasing by 28 percent. Numerical abundance continued to increase in 1991 and 1992, by 14 percent and 16 percent, respectively.

Biomass estimates for the Aleutian Islands region were derived from U.S.-Japan cooperative surveys (covering 170 degrees east to 170 degrees west) conducted during the summers of 1980, 1983, 1986, and 1991. The overall trend indicates a sizable increase in the biomass of Pacific cod in the Aleutian region, as shown in Table 3.2.

A stock assessment model has been tuned to catch-at-length data from the commercial fishery and numbers-at-length and total biomass data from the trawl survey. The abundance trends exhibited by the model and survey are very similar. Both show that stock biomass is declining from the relatively high levels observed during the 1980s.

3.1.4 Recruitment

The high biomass levels observed during the 1980s can be attributed largely to the excellent 1977 year class and to good year classes spawned in 1982 and 1984. However, the 1986-1988 year classes appear to be well below average in strength, despite having been spawned at a time when stock biomass was at a peak. The 1987 year class (measured at age 3) is the poorest on record.

Nevertheless, recruitment of the 1989 year class at age 3 in 1992 was above average, and the available evidence indicates that the 1990 year class (to recruit at age 3 in 1993) should also be stronger than average. The correlation between prerecruit abundance as measured by the trawl survey and future recruitment as observed in the commercial catch is far from perfect, however, so the evidence of a stronger-than-average 1990 year class must be regarded as tentative at present.

3.1.5 Ecosystem Considerations

Pacific cod population dynamics do not seem to be related only to age structure and fishing mortality. Undoubtedly, ecosystem considerations play a fundamental role as well. Among the potentially important ecosystem considerations is prey abundance. Livingston (1991) found that the following taxa were the most important items in the diet of EBS Pacific cod:

By Occurrence	%	By Number	%	By Weight	%
Polychaetes	46.3	Euphausids	25.5	Walleye pollock	39.3
Amphipods	42.8	Misc. fish	17.7	Fishery discards	13.1
Crangonid shrimp	36.9	Amphipods	14.9	Yellowfin sole 6.0	

Notes: 1) Percent occurrence figures may sum to a number greater than 100.
2) "Fishery discards" are carcasses which can be identified as having passed through a filleting machine.

Although no individual crab species ranks among the top three items in the diet of EBS Pacific cod, the snow and Tanner crab species (*Chionocetes* sp.) together accounted for 8.8% of cod stomach contents by weight in Livingston's (1991) study. In addition, Livingston (1989) found that predation by Pacific cod might have consumed 84-95 percent of the population of age 1 *C. bairdi* in 1981-1985 and 27-57 percent of the population of *C. opilio* during the same time period. Pacific cod predation on red king crab (*Paralithodes camtschatica*) did not seem particularly significant in Livingston's studies.

3.2 Estimates of the Effects on Equilibrium Yield per Recruit of Alternative Gear Allocations and Seasons

The data and model on which the estimates of yield per recruit are based are the topic of Appendix E. Table 3.3 shows the catch distribution for the combined period 1991-1992. Estimates of the equilibrium yield per recruit for the 1991-92 distribution of catch and for alternative distributions are presented in Table 3.4. The estimates are based on the assumption that the stock is harvested at the F35 percent rate.

Due to uncertainty concerning the age/size at 50 percent maturity, estimates were made for two alternative assumptions concerning the value of that parameter.

With a length at 50 percent maturity of about 61 cm and with 5 percent of the catch being taken with pot gear, the estimated equilibrium yield per recruit is 1.1 kg when the trawl and longline fisheries account for 75 percent and 20 percent of the catch, respectively, as well as when those percentages are reversed. With a length at 50 percent maturity of about 48 cm, the change from 75-20 percent to 20-75 percent increases yield per recruit by less than 2 percent. The results were the same whether the change in the trawl harvest was proportional for the two seasons or whether it was made principally to the harvest in the first season. The estimates reported in Table 3.4 are for the former case. These results indicate that, within a broad range, the distribution of the cod catch between the longline and trawl fisheries does not have a significant effect on yield per recruit. Although no formal sensitivity analysis has been conducted, a difference of less than 2 percent is almost certainly well within any reasonable confidence interval.

Substantially larger increases in equilibrium yield per recruit occur when catch in the pot fishery replaces longline and/or trawl catch. In the extreme, when pot catch in increased from the 1991-92 level of 5% to 100 percent, estimated equilibrium yield increases by 8.9 percent or 11.5 percent, respectively, with a length at 50% maturity of about 61 cm or 48 cm.

Another alternative would be to adjust the percent composition of the catch by period. A split of 65/10/25 has been suggested (basically just reversing the catch proportions currently taken in the second and third periods). However, since no gear type currently takes more than 20 percent of its catch in Period 3, this split is not possible without varying the percentage composition by period within gear shown in Part A of Table 3.3. If these percentages are freed, an alternative means of constraining the solution is to fix the percentage composition by gear within period at the values shown in Part B of Table 3.3. Then, if the stock is harvested at the F35 percentage rate and the catch is allocated by period according to the 65/10/25 scenario, the solution shown in Table 3.5 is obtained.

The 65/10/25 seasonal allocation scenario has virtually no effect on either the target fishing mortality rate or the equilibrium yield per recruit. Instead, the chief effect would be to reallocate about 3% of the annual catch from trawlers to longliners.

3.3 Impacts of Trawling on the Seabed and Benthic Community

In addition to its impacts on target species, fishing can also have impacts on non-target species and the seabed itself. Trawl gear, in particular, has attracted considerable attention in terms of its potential impact on non-target species and the seabed. Most of these studies have been conducted in the North Sea. Not only is trawl effort especially high in the North Sea, but concern there over the use of trawl gear has a history dating back several centuries.

Areas of potential impact that have been investigated include physical impacts on the seabed (plowing), sediment resuspension, destruction of nontarget benthos, long-term impacts on the structure of the benthic community, change in forage availability, and grounds preemption. The information available for each of these areas is summarized in Appendix F. The conclusions are presented below.

It is clear that trawling can impact both the seabed and the benthic community. The extent of these impacts depends on the weight of the gear, the towing speed, the nature of the bottom, and the strengths of tides and currents. Bottom trawl doors leave scars on the seabed that can last for minutes, hours, or years. Trawls can damage benthic organisms, thereby causing changes in community species composition and population age structure, but perhaps also leading to an increase in the availability of forage for commercial species. Whether changes in community species composition would tend to come at the

expense of commercially important species such as crab is difficult to determine. In any case, it is important to remember that the impacts described here become relevant only if any of the alternatives examined in this amendment result in a change in the *total amount* of trawling in an area, as opposed simply to a change in the amount of trawling for Pacific cod which is offset by an increase in the amount of trawling for other species in the same area.

3.4 Effects of Fishing on Spawning Cod Stocks

Two approaches are taken to address the effects of fishing on spawning cod stocks. First, the practice of fishing on spawning stocks and research concerning its effects are summarized. Second, the potential problem is considered from a theoretical perspective. The following summaries for these two approaches are based on the information contained in Appendices G and H.

3.4.1 Review of the Effect of Fishing on Spawning Stocks

Fishing on pre-spawning and spawning aggregations of fish has a long history. In Norway, the cod fishery in the Lofoten Islands has been fished commercially during the spawning period as far back as the middle ages. Likewise, herring have been fished on Norwegian coastal spawning banks for an equally long time. In general, herrings, cods, capelin, and some flatfish species are fished on the spawning grounds because of high catch rates and the higher economic value of roe bearing fish.

The question of the effects of fishing on spawning fish has been repeatedly raised for various stocks of fish, most recently as part of an inquiry into the status of the northern cod stock off Labrador and Newfoundland, Canada (Harris 1990). Section 6.7.0 of the report addresses Fishing on Spawning Stocks and Groups. The conclusion of that report is that there is no clear deleterious effect of fishing on spawning concentrations of cod or other marine fishes. However, as the Canadian northern cod study points out, there may be subtle effects that cannot be readily detected. Nevertheless, the history of fisheries does not indicate that fishing during the spawning period only has led to any measurable biological changes or cause reduced survival of prodigy.

In some Atlantic cod fisheries the fishery is closed during the period of peak spawning, and fishing is prohibited during the time of day that active spawning takes place, usually at night. This may help to minimize behavioral effects from fishing, but there are no substantiating data. Pacific cod produce demersal eggs that are deposited on bottom. Prohibition of on-bottom trawling may protect developing eggs. It is impossible to say what various measures employed to regulate fisheries on spawning Atlantic cod would have on Pacific cod. The location of spawning grounds off Alaska is only generally known. Specific spawning behavior, the time of peak spawning, and the extent of interannual variation in timing of peak spawning are unknown.

3.4.2 A Theoretical Perspective

Looking at the problem from a theoretical perspective, the overall issue can be broken into three parts. First, there is the question of whether fishing on spawning stocks early in the year might lead to a reduction in stock size. Second, there is the question of whether it might lead to a reduction in catch. Third, there is the question of whether either of these phenomena poses a problem with respect to establishing the correct TAC and preventing the TAC from being exceeded.

The first two questions, with respect to sustainable yield and the level of the spawning biomass, are addressed in Appendix H. Although a number of strong assumptions are employed, the model presented there seems to be the best available. The model treats the length of the fishing season as the management variable of interest (i.e., it assumes that the target survival rate is given), and measures both stock size

and catch in terms of numbers. The main conclusions are that fishing on spawning stocks early in the year does tend to reduce equilibrium stock size, while equilibrium catch can either increase or decrease, depending on parameter values.

The model presented in Appendix H does not consider the possibility that harvesting during the spawning season might have adverse behavioral effects on the spawning fish (i.e., it treats a change in the *number*, not the *behavior*, of spawning fish as the means by which future recruitment is modified). For the present, the extent of such behavioral effects is conjectural. If these effects are (or were to become) significant, however, they would tend to increase the likelihood of fishing on spawning stocks early in the year leading to a reduction in stock size or TAC.

The third question revolves mostly around two issues. They are the extent to which the level of fishing early in the year is predictable and the ability to prevent the TAC from being exceeded. In the model used to assess the eastern Bering Sea cod stock, for example, intraannual effort distribution is incorporated explicitly. So long as the percent of the catch that occurs early in the year is consistent, no difficulty is presented, since this pattern of effort distribution will be incorporated in the estimation of ABC. The main potential for harm comes when the pattern of effort distribution is skewed suddenly and dramatically relative to the previous years' pattern. Given the present size of the cod stock, it is unlikely that even a fairly dramatic shift toward harvest early in the year would prove truly dangerous (in the sense of posing a danger to the long-term viability of the stock), although it could certainly be suboptimal in the short run.

The other potential concern is that due to the higher CPUE the fishery is much more intensive and the potential for exceeding the TAC is increased. However, the existing monitoring capabilities combined with the 15 percent reserve are expected to prevent this from being a significant problem for the long term productivity of the cod stocks.

In summary, fishing on spawning stocks early in the year does have the potential for reducing stock sizes and catches, which is certainly a valid concern for management. The extent (if any) to which this potential is realized at present or under any likely future scenario, however, is unknown. In any case, should fishing early in the year become an established pattern, stock assessments should be able to incorporate this factor into the process of estimating ABC so that it does not pose a long-term problem with respect to the biological viability of cod resource.

3.5 Gear-Specific Effects on Marine Mammals

Potential gear-specific effects on marine mammals are summarized in this section. A more complete discussion of this issue is presented in Appendix I.

Based on gear-specific differences in the rates of incidental takes, the temporal and spacial distribution of catch, bycatch rates, and cod length frequencies, the cod trawl fishery probably has a slightly higher potential for having an adverse effect on marine mammal populations other than killer whales. Data from the fisheries and scientific surveys indicate that there are more direct interactions between killer whales and longline gear than with other types of gear, but this interactions is principally with the sablefish and turbot longline fishery, not the cod fishery. Neither the absolute level of that potential nor the difference of that potential among cod fisheries is expected to be large enough to have a statistically significant effect on these populations. The potential for a reduction in the cod harvest in the trawl fishery to enhance marine mammal populations would also tend to be reduced by the resulting redeployment of trawl effort to other BSAI groundfish fisheries.

3.6 Gear-Specific Effects on Seabirds

The following table lists the observed incidental take of seabirds by area and gear type for 1991. The numbers reported are extrapolated to whole hauls/sets for observed fishing operations. All seabirds taken 1990-1992 are recorded under a single code for unidentified bird, precluding the reporting of these numbers by species or species groups. Therefore, it is not known how many of the incidental takes are of species for which there is currently a substantial management concern. Preliminary attempts to determine whether much of the incidental take consists of such species should be completed before June 1993.

Summary of observed incidental take of seabirds by area and gear type in 1991. Bird numbers and weights are extrapolated to whole hauls for observed fishing operations only. Take rate is expressed as a percent, [((operations with birds)/(total observed operations)) x 100].

		Operations				
Area	Gear Type	Observed	With Birds	Total Birds	Total Wt. (Kg)	Take Rate
GOA	Bottom Trawl	4,076	0	-	-	0.0
	Pelagic Trawl	1,058	0	-	-	0.0
	Pair Trawl	4	0	-	-	0.0
	Pot	779	0	-	-	0.0
	Longline	1,585	35	148	186.14	2.2
BSA	Bottom Trawl	13,335	0	-	-	0.0
	Pelagic Trawl	14,592	17	1,516	1,455.17	0.1
	Pair Trawl	101	2	2	2.60	2.0
	Pot	1,117	4	8	9.60	0.4
	Longline	7,050	821	9,946	13,849.20	11.6

Based on gear-specific differences in the rates of incidental takes the cod longline fishery probably has a slightly higher potential for having an adverse effect on marine seabird populations. However, neither the absolute level of that potential nor the difference of that potential among cod fisheries is expected to be large enough to have a statistically significant effect on these populations and it is not known whether the higher incidental take rates in the longline fishery are of species for which there is a management problem.

3.7 Bycatch of Groundfish and Prohibited Species

The bycatch of groundfish and prohibited species in the cod fisheries is determined in part by the distribution of cod catch by fishery and season. Therefore, management actions that will change that distribution will have an effect on bycatch. However, the groundfish TACs, PSC limits, and other existing bycatch management measures are expected to prevent the resulting changes in bycatch in the cod fisheries from having significant effects on the long term productivity of the groundfish or prohibited species stocks.

Any resulting change in bycatch in the cod fishery as a whole probably would be offset at least partially by the redeployment of fishing effort to other groundfish fisheries. Any net change in bycatch mortality in the groundfish fishery as a whole would tend to have most of its effect on future target fishery quotas

for the species taken as bycatch in the groundfish fisheries. For example, the IPHC adjusts the quota for the halibut fishery to prevent halibut bycatch mortality in the groundfish fishery from affecting the reproductive potential of the halibut stocks. In the past, the IPHC has indicated that, due to these adjustments to halibut fishery quotas, halibut bycatch mortality for the groundfish fishery as a whole could increase or decrease by 50 percent and not have a significant effect on the long term productivity of the halibut stocks.

Unless a stock that is subject to bycatch mortality in the cod fisheries is at such a critically low level that no commercial fishery targets on it and unless the differences in bycatch that would result among the alternatives being considered are sufficiently large that some would have an adverse effect on the potential for such a stock to recover, bycatch in the cod fisheries affects future catch in other fisheries but not the long term productivity of the stocks subject to that bycatch. Estimates of the cost of bycatch in terms of foregone catch in other fisheries were discussed in Chapter 2 and are used in Chapter 4 to estimate the economic effects of the alternatives.

3.8 Exceeding the Cod TAC and Cod Fishery PSC Allowances to Change the Fishing Year

With the current fishing year, most, if not all, of the cod TAC and the cod fishery halibut PSC allowances are expected to be taken before September 1. Therefore, if the fishing year is changed from January 1-December 31 to September 1-August 31, there will be little or no TAC or halibut PSC allowances to start a new fishing year September 1. There are two possible solutions. The cod fisheries could remain closed until September 1 of the following year, that is, there could be a closure of more than 12 months. Alternatively, the cod fishery could be opened on September 1 of the current year with the understanding that the cod TAC and the cod fishery halibut PSC allowances would be exceeded for that calendar year. Based on historical performance in the foreign, joint venture, and domestic cod fisheries during the period of September through December, it probably is not unrealistic to assume that 50 percent or more of the annual TAC and PSC allowances could be taken between September and December.

An overage of the halibut PSC allowances for the cod fisheries would be expected to reduce quotas in the halibut fishery, but not to reduce the long-term productivity of the halibut stocks. A one time 50 percent overage of the Pacific cod TAC may be more of a concern. If the 1993 cod TAC of 164,500 mt will have been taken by the end of August, an additional 27,500 mt could be taken in September-December without exceeding the over fishing level of 192,000 mt. The peak monthly catch in the cod longline and cod trawl fishery since 1990 were 17,900 mt and 43,100 mt, respectively. This suggests that the 27,500 mt difference between the cod TAC and overfishing level would not support a 4-month fishery beginning September 1, 1993. It is not clear under what circumstances the overfishing level could be exceeded one calendar year to allow a change to a September-August fishing year for cod nor is it clear what level of overage would be acceptable.

3.9 Biological effects of the preferred alternative

The biological effects of the preferred alternative described in section 1.6 of this document are summarized below.

1. Expected Effects on the Biological Productivity of the BSAI Cod Resource

The distribution of cod catch among the cod fisheries and among seasons may affect the biological productivity of the BSAI cod resource through its effects on yield per recruit and due to the effects of fishing on pre-spawning or spawning aggregations of cod. The latter includes direct effects on stock size, equilibrium yield, spawning success, and the ability to monitor successfully the attainment of the TAC.

There are two reasons why the preferred alternative is not expected to have a significant effect on the biological productivity of the BSAI cod resource. First, the preferred alternative is expected to result in very little change in the distribution of cod catch by gear or season. Second, substantially larger changes in the distribution of catch by gear and season are not expected to have measurable effects on the cod resource.

2. Expected Effects on Marine Mammals and Seabirds

A change in the distribution of cod catch among fisheries and/or seasons that has adverse effects on marine mammals and seabirds can impose two types of economic costs. It can decrease the value of the those marine resources and it can result in more costly restrictions being placed on the commercial fisheries. However, the current cod fisheries' interactions with marine mammals and seabirds are not thought to be large enough to have statistically significant effects on their populations. The differential effects between the status quo and the preferred alternative are even smaller. Therefore, the preferred alternative is not expected to differ significantly from the status quo with respect to effects on marine mammal and seabird populations.

3. Impacts of Trawling on the Seabed and Benthic Community

Even if trawling had a demonstrated effect on the seabed and benthic community, the preferred alternative would be expected to have little or no effect because the preferred alternative is not expected to have a significant effect on the level of trawling in the cod or other groundfish fisheries.

4. Expected Effects of Changes in the Bycatch of Prohibited Species

The authority provided by the preferred alternative to allocate the longline and pot gear cod apportionment by season is expected to shift some longline cod catch from the second season to the third season. This will tend to decrease halibut bycatch mortality in the longline fishery.

The current levels of prohibited species bycatch in the cod fisheries are expected to decrease catch in the fisheries that target on these species but not decrease the long term productivity of the stocks. Although there can be exceptions in which bycatch in the cod fisheries could have an adverse effect on long term productivity, such exceptions have not been identified for the cod fishery and certainly not for the bycatch differences expected between the preferred alternative and the status quo.

References

Livingston, P. A. 1989. Interannual trends in Pacific cod, *Gadus macrocephalus*, predation on three commercially important crab species in the eastern Bering Sea. Fish. Bull., U.S. 87:807-827.

Livingston, P. A. 1991. Pacific cod. In P. A. Livingston (editor), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1984 to 1986, p. 31-88. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-207.

Table 3.1 Estimates of total abundance from Alaska Fisheries Science Center demersal trawl surveys on the Eastern Bering Sea shelf, 1979-92.

Year	Biomass (t)	95% Confidence Int. (t)	Numbers
1979	754,314	562,539 - 946,089	1,530,429,650
1980	905,344	733,063 - 1,077,624	1,084,147,540
1981	1,034,629	791,885 - 1,277,373	794,619,624
1982	1,020,550	876,701 - 1,164,399	583,715,089
1983	1,176,305	937,958 - 1,414,651	725,351,369
1984	1,001,940	876,251 - 1,127,629	636,948,300
1985	961,050	860,203 - 1,061,896	800,070,473
1986	1,134,106	993,353 - 1,274,858	843,460,794
1987	1,142,450	1,002,430 - 1,282,468	754,269,021
1988	959,544	810,028 - 1,109,060	509,336,483
1989	960,436	824,888 - 1,095,984	339,719,445
1990	708,551	603,245 - 813,857	435,856,535
1991	532,590	450,902 - 614,279	496,841,261
1992*	546,707	457,030 - 636,383	577,416,832

*During the 1992 field season, 18 stations were omitted from the standard survey grid due to severe weather and vessel problems. In 1989, 1990, and 1991, these 18 stations represented, on average, 2.2% and 2.8% of the total Pacific cod biomass and numbers, respectively. The 1992 point estimates and confidence interval shown above have been adjusted upward proportionately.

Table 3.2 Pacific cod biomass estimates for the Aleutian Islands region derived from U.S.-Japan cooperative surveys (covering 170 degrees east to 170 degrees west) conducted during the summers of 1980, 1983, 1986, and 1991.

Year	Biomass
1980	78,800 t
1983	136,900 t
1986	181,700 t
1991	169,600 t

Table 3.3. Composition of the 1991-1992 Pacific cod catch.
Percent (%)

A. Focus on gear

Percent composition of catch by gear:		Percent composition of catch by period within gear (rows sum to 100):			
			Period 1	Period 2	Period 3
Trawl	52%	Trawl	83%	14%	3%
Longline	43%	Longline	50%	32%	18%
Pot	5%	Pot	22%	58%	20%

B. Focus on period

Percent composition of catch by period:		Percent composition of catch by gear within period (rows sum to 100):			
			Trawl	Longline	Pot
Period 1	66%	Period 1	65%	33%	2%
Period 2	24%	Period 2	30%	59%	11%
Period 3	10%	Period 3	17%	74%	9%

Table 3.4 Results from various gear allocation scenarios.
Percent (%)

		Maturity #1		Maturity #2		
Trawl	Longline	Pot	F35%	YPR	F35%	YPR
52%	43%	5%	0.34	1.01	0.53	1.13
100%	0%	0%	0.34	0.99	0.51	1.10
0%	100%	0%	0.33	1.01	0.52	1.15
0%	0%	100%	0.49	1.10	0.89	1.26
75%	20%	5%	0.35	1.01	0.53	1.12
20%	75%	5%	0.34	1.01	0.53	1.14
60%	20%	20%	0.37	1.02	0.58	1.14
20%	60%	20%	0.37	1.03	0.58	1.16

Note: The columns labeled "Maturity #1" utilize the maturity-at-length schedule that has been employed for the past several years in the Pacific cod stock assessment (with a length at 50% maturity of about 61 cm). The columns labeled "Maturity #2" utilize an alternate maturity-at-length schedule (with a length at 50% maturity of about 48 cm).

Table 3.5 Results from a 65/10/25 seasonal allocation.
Percent (%)

Percent composition of catch by gear:

Percent composition of catch by period within gear (rows sum to 100):

			Period 1	Period 2	Period 3
Trawl	49%	Trawl	85%	6%	9%
Longline	46%	Longline	46%	13%	41%
Pot	5%	Pot	28%	23%	49%

Maturity #1		Maturity #2	
F35%	YPR	F35%	YPR
0.34	1.00	0.53	1.12

4.0 ECONOMIC AND SOCIAL ANALYSES OF THE ALTERNATIVES

The economic and social analyses of the alternatives are principally in terms of the following:

1. Expected effects on the biological productivity of the BSAI cod resource;

2. Expected effects on marine mammals and seabirds;

3. Impacts of trawling on the seabed and benthic community;

4. Expected effects of changes in the bycatch of prohibited species;

5. Expected effects on coastal community stability;

6. Historical use of the fishery;

7. Current dependence on the fishery;

8. Expected effects on economic benefits to the Nation;

9. Expected distribution effects;

10. Expected effects on consumers;

11. Expected effects on the competitiveness of the U.S. fishing industry; and

12. Expected effects on reporting, management, enforcement, and information costs.

Information concerning the expected biological effects of the alternatives with respect to the first four criteria is presented in Chapter 3 and Appendices E-I. Therefore, this chapter presents only brief summaries of that information and brief discussions of the economic and social implications of the expected biological effects. The discussions of the alternatives in terms of the other criteria are based principally on information contained in Chapter 2 and Appendices A-D.

4.1 Evaluation of Changing the Distribution of Cod Catch by Cod Fishery and Season

The effects of changing the distribution of cod catch by cod fishery and season are considered in Sections 4.1.1 - 4.1.12 in terms of the 12 criteria. Other aspects of the alternatives being considered are addressed in Section 4.2.

4.1.1 Expected Effects on the Biological Productivity of the BSAI Cod Resource

The distribution of cod catch among the cod fisheries and among seasons may affect the biological productivity of the BSAI cod resource through its effects on yield per recruit and due to the effects of fishing on pre-spawning or spawning aggregations of cod. The latter includes direct effects on stock size, equilibrium yield, spawning success, and the ability to monitor successfully the attainment of the TAC.

Effect on yield per recruit

The yield per recruit model indicated that yield per recruit is not affected either by large changes in the distribution of cod catch between the cod longline and cod trawl fisheries or by a change from the current

seasonal distribution to a 65 percent, 10 percent, and 35 percent distribution among seasons. However, an increase in the percent of catch taken in the cod pot fishery did increase yield per recruit. Therefore, with one exception, none of the alternatives being considered is expected to have a measurable economic effect through its effect on yield per recruit. The exception is that an increase in yield would result from an increase in the percent of catch taken with pot gear. That would be expected to increase the sustainable catch and economic yield of the cod fishery.

<u>Effect on stock size and equilibrium yield</u>

The main conclusions of the theoretical model presented in Appendix H are that fishing on spawning stocks early in the year does tend to reduce equilibrium stock size, while equilibrium catch can either increase or decrease, depending on parameter values.

<u>Effects on spawning success</u>

The question of the effects of fishing on spawning fish has been raised repeatedly for various stocks of fish, most recently as part of an inquiry into the status of the northern cod stock off Labrador and Newfoundland, Canada (Harris 1990). Section 6.7.0 of the report addresses <u>Fishing on Spawning Stocks and Groups</u>. The conclusion of that report is that there is no clear deleterious effect of fishing on spawning concentrations of cod or other marine fishes. However, as the Canadian northern cod study points out, there may be subtle effects that cannot be readily detected. Nevertheless, the history of fisheries does not indicate that fishing during the spawning period only has led to any measurable biological changes or cause reduced survival of prodigy.

Operational restrictions to limit fishing on spawning stocks have been implemented in some fisheries, including the BSAI pollock fishery. They have been implement for a variety of reasons. Although concern for spawning success may be among the reasons, it has not always been the principal reason for such restrictions. Such restrictions are easier to justify when a stock is heavily overexploited or at very low levels for other reasons and any action that may aid in the stock's recovery is of greater benefit. The BSAI cod stocks do not meet these conditions.

If the decision is made to assume that spawning success is affected adversely by the level of catch during the first season, there are two alternative actions that should be considered to offset the associated potential decrease in sustainable yield. One is to reduce catch during the first season. The other is to reduce the TAC but not catch during the first season. If the net benefit per mt of cod catch is sufficiently greater the first season than later in the year, the second alternative is preferable. The estimates of net benefit per mt of cod catch by fishery and season for 1991 and 1992 indicate that the benefits per ton of cod catch are much larger the first season and that the latter alternative should be considered.

<u>Effect on the ability to monitor successfully the attainment of the TAC</u>

The higher catch per unit of effort during the first season and the large harvesting capacity of the vessels that have participated in the cod fisheries during the first season have resulted in higher daily catch rates during the first season. This increases the difficulty of projecting when the TAC will be taken. However, with the exception of a bycatch reserve, the 1993 TAC is expected to be taken during the first season without creating a substantial monitoring problem. Over the past few years, continuous improvements in NMFS monitoring capabilities have substantially decreased the potential for significantly exceeding a TAC for fisheries that last more than a few weeks. The BSAI cod fishery is expected to continue to be in that category of fisheries. The fact that there is very high observer coverage for the BSAI cod fisheries increases the potential for successfully monitoring catch regardless of its seasonal distribution.

4.1.2 Expected Effects on Marine Mammals and Seabirds

A change in the distribution of cod catch among fisheries and/or seasons that has adverse effects on marine mammals and seabirds can impose two types of economic costs. It can decrease the value of the those marine resources and it can result in more costly restrictions being placed on the commercial fisheries. However, the current cod fisheries' interactions with marine mammals and seabirds are not thought to be large enough to have statistically significant effects on their populations. The differential effects among the alternatives being considered are thought to be even smaller. The potential differences are reduced by the expected redeployment of effort for each fleet participating in the cod fishery if its cod catch is reduced. Even though the fact that the 2.0 million mt optimum yield (OY) for the BSAI groundfish fishery was apparently taken or exceeded in both 1991 and 1992 suggests that the effective redeployment will be severely limited, the alternatives being considered are not expected to have significant economic effects through their effects on marine mammal and seabird populations.

4.1.3 Impacts of trawling on the seabed and benthic community

Trawl gear, in particular, has attracted considerable attention in terms of its potential impact on non-target species and the seabed. Most of these studies have been conducted in the North Sea. Not only is trawl effort especially high in the North Sea, but concern there over the use of trawl gear has a history dating back several centuries. The studies discuss both adverse and positive effects of bottom trawling and note that each depends on several variable factors. It is important to remember that the potential impacts of bottom trawling become relevant only if any of the alternatives result in a change in the *total amount* of trawling in an area, as opposed simply to a change in the amount of trawling for Pacific cod which is offset by an increase in the amount of trawling for other species in the same area.

Neither the direction nor the magnitude of the effects of bottom trawling are clear and any differences in impacts among the alternatives are expected to be offset to some extent by a redeployment of trawl effort within the groundfish fishery as a whole. Even though the fact that the 2.0 million mt OY for the BSAI groundfish fishery was apparently taken or exceeded in both 1991 and 1992 suggests that the effective redeployment will be severely limited, it is not clear that the alternative-specific difference in the impacts on the seabed and benthic organisms will have measurable economic effects.

4.1.4 Expected Effects of Changes in the Bycatch of Prohibited Species

Due to differences in bycatch rates by fishery and season, changes in the distribution of cod catch by fishery and season can change the bycatch of prohibited species in the cod fishery. However, such changes would be modified by any associated redeployment of effort to other groundfish fisheries. Ignoring the bycatch effects of the redeployment of effort, some of the implications of the historical bycatch mortality rate data are listed below. Given that the 2.0 million mt OY for the BSAI groundfish fishery was apparently taken or exceeded in both 1991 and 1992, the effective redeployment will be severely limited and, therefore, ignoring the redeployment effects probably will not result in a substantial error.

1. Halibut bycatch mortality can be decreased by:

    a. Taking all of the longline catch during the first season;
    b. Replacing first season trawl catch with first season longline catch; and
    c. Replacing any trawl or longline catch with pot catch.

2. Given recent halibut discard mortality rates, bycatch rates, and the resulting bycatch mortality rates, decreasing cod trawl catch during the first season in order to increase cod longline

catch the third season could result in either a small increase or decrease in halibut bycatch mortality in the cod fisheries.

3. Herring bycatch mortality can be decreased by replacing trawl cod catch with longline or pot cod catch. If the cod trawl fishery is eliminated, total herring bycatch in the BSAI groundfish fishery would be reduced by 0.6 percent based on 1992 data.

4. Crab bycatch can be reduced by replacing pot catch with trawl catch or by replacing trawl catch with longline catch. If the cod trawl and pot fisheries are were eliminated, total red king and Tanner bycatch mortality, respectively, in the BSAI groundfish fishery would be reduced by less than 2 percent and by less than 7 percent based on 1992 data.

5. Chinook salmon bycatch can be reduced by replacing trawl catch with longline or pot catch. If the cod trawl fishery were eliminated, total chinook salmon bycatch in the BSAI groundfish fishery would be reduced by 11.6 percent based on 1992 data.

The current levels of prohibited species bycatch in the cod fisheries are expected to decrease catch in the fisheries that target on these species but not decrease the long-term productivity of the stocks. Although there can be exceptions in which bycatch in the cod fisheries could have an adverse effect on long term productivity, such exceptions have not been identified for the cod fishery and certainly not for the bycatch differences expected among the alternatives being considered. The economic effects of decreased catch in other fisheries are considered in the calculation of net benefits (Section 4.1.8).

4.1.5 Expected effects on coastal community stability

The alternatives being considered can affect the stability of coastal communities in several ways. The seasonal distribution of cod catch can affect the seasonal stability of the coastal communities impacted by the BSAI cod fisheries. However, given the seasonality of all other fisheries, it is not clear what changes in the seasonal distribution of cod catch would be beneficial to specific communities.

Community stability is also a function of the level of economic activity supported by the cod fisheries. A redistribution of catch from the cod trawl fishery to the cod longline fishery would decrease the level of economic activity in those communities where BSAI cod is processed. This is because a much larger percent of the cod catch from the trawl fishery is processed on shore. For example in 1992, 21 percent of the cod catch in the cod trawl fishery was for onshore processing compared to only 1 percent for the cod longline fishery (Table A13). The differences were about the same in 1990-92. Although the percent of catch for onshore processing was higher in the 1992 pot fishery than in the trawl fishery, in both 1990 and 1991 the percent was higher in the trawl fishery.

Community stability can also be affected by the effect the distribution of catch has on the economic viability of existing fishing and processing operations. With respect to this issue, there are both immediate and long-term considerations. The decision to reduce the amount of cod available to any one of the three cod fisheries may result in some operations going out of business. However, given that the cod fishery is overcapitalized, some operations may fail even if the distribution of catch among the three cod fisheries is not changed. It is not known what the immediate effect of the alternatives would be in terms of business failures and the resulting instability of associated coastal communities.

The long-term consideration has to do with the ongoing economic viability of participants in the cod fishery as a whole. Increasing the allocation either to less profitable participants or to participants with more specialized operations would tend to decrease the economic viability of the fishery during periods of less favorable market and regulatory conditions. Due to the substantial fluctuations that can occur in

TACs and market conditions, it is advantageous to have vessels that can switch efficiently from one fishery to another. Therefore, all else being equal, an action that encouraged the development of specialized vessels that cannot change fisheries readily would not be desirable. Even within a year, the ability of a vessel to operate in various fisheries is an advantage in terms of being able to fish throughout the year. Although profitability is thought to vary substantially within each cod fishery and to overlap among the three cod fisheries, the factory longliners appear to be the most specialized operations in the cod fisheries.

4.1.6 Historical use of the cod fishery

For the domestic (DAP) groundfish fishery in the BSAI, trawl gear was dominant from 1981-92. However, its dominance decreased rapidly beginning in 1989 (Table A4). Trawl gear accounted for 100 percent of the domestic fishery cod catch from 1981 through 1986, 97 percent in each of the next two years, but only 44 percent in 1992. The percent of the domestic fishery cod catch taken with longline gear increased from 0 percent in 1986 to 3 percent in 1987 and 1988 and then increased very rapidly reaching 49 percent for 1992.

For the 12-year period as a whole, the total joint venture and domestic (DAH) cod catch was about 1,438,000 mt and the cod catch in the domestic fishery alone (DAP) was about 1,044,000 mt. Approximately 81 percent of the DAH cod catch and 74 percent of the DAP cod catch were taken with trawl gear, 17 percent of the DAH cod catch and 24 percent of the DAP cod catch were taken with longline gear, and only 1.6 percent of the DAH cod catch and 2.2 percent of the DAP cod catch were taken with pot gear.

The percent of total DAP cod catch accounted for by each of the three cod fisheries and all other fisheries for 1990-92 is as follows:

	Pacific Cod Fisheries			Other	Total
	Longline	Pot	Trawl	Fisheries	
1990	28.3	0.8	51.8	19.0	100.0
1991	36.5	3.1	41.3	19.1	100.0
1992	49.1	6.7	23.3	20.8	100.0
1992 adj	39.2	7.4	30.2	23.2	100.0.

The adjusted catch estimates for 1992 (1992 adj) are estimates of what the 1992 catches would have been: (1) if the full cod trawl fishery halibut PSC bycatch allowance of 2,359 mt had been available for the cod trawl fishery, (2) if the longline fishery had been closed once its 750 mt halibut bycatch mortality allowance had been taken, and (3) if the blend estimates of catch had been used to estimate when the cod TAC and each of these two PSC allowances were taken.

The increase in the percent of catch taken with longline and pot gear was in part the result of cod trawl fishery closures beginning in 1989 due to halibut PSC allowances being taken. The closures (Table A5) provided improved market and regulatory opportunities for the use of non-trawl gear. These opportunities increased participation in the cod fishery by vessels that had been designed to use longline or pot gear and by trawl vessels that were refitted to use fixed gear either just during trawl closures or during the entire fishing year.

4.1.7 Current dependence on the cod fishery

The cod factory longline fleet as a whole is much more dependent on the BSAI cod fishery in terms of either weeks of operation or product value than is the cod factory trawler fleet. However, within each fleet there are vessels that are highly dependent on the BSAI cod fishery and there are other vessels that have a very low level of dependence on the BSAI cod fishery. Similarly, the cod longline catcher boat fleet as a whole was more dependent on the BSAI cod fishery in terms of weeks of operation and much more dependent in terms of exvessel value than is the cod trawl catcher boat fleet. However, within each fleet there are vessels that are highly dependent on the BSAI cod fishery and there are other vessels that have a very low level of dependence on the BSAI cod fishery. The measures of dependence and more detailed conclusions were presented in Section 2.2.7.

The dependence of a vessel on a fishery is also determined by its ability to be refitted to participate in other fisheries. Typically it is much less difficult to refit a trawler to use longline gear than it is to refit a longline vessel to use trawl gear. The reasons for this include the following: substantially greater horsepower is required for trawling; the physical configuration of a vessel including the placement of the wheel house and gear on many longline vessel would make the conversion to trawling very difficult; and trawlers typically have a large open deck with the space for the gear and sheltered deck usually used for longlining.

This difference can be used more effectively to argue against an action that will decrease cod catch with non-trawl gear than to argue in support of an action that will increase catch with non-trawl gear. To the extent that the former would displace vessels that could not readily enter the trawl fishery, a high cost could be imposed on those associated with the displaced vessels. However, to the extent that the latter would result in vessel conversions to non-trawl gear, the conversion costs may be substantial. Basically, a change from the current distribution of catch will impose adjustment costs that include displacing some vessels and perhaps building new vessels and modifying existing vessels.

4.1.8 Expected effects on economic benefits to the Nation

Estimates of net benefits per mt of cod catch (ANB) by cod fishery and season for 1991 and 1992 were presented in Section 2.2.13. Despite the fact that the determinants of ANB are variables that change over time and despite the other stated limitations of the estimates for 1991 and 1992, those estimates of ANB probably provide the best available indication of how a change in the distribution of cod catch among cod fisheries and seasons would affect an important subset of net benefits to the Nation. That subset of net benefits combined with the other effects considered elsewhere in this report address the principal determinants of net benefits from the cod fisheries.

It is very difficult to estimate how ANB will change over time by fishery and season. The detail that is provided, in terms of the components of the estimates of ANB, facilitates estimating how a specific change in a determinant of ANB would affect the estimates of ANB. For example, if it is assumed that the discard mortality rate in the cod longline fishery will be reduced by 50 percent, the estimate of ANB in that fishery would be increased by 50 percent of the current estimate of the halibut bycatch cost per mt of cod catch. Not only is each such change in the determinant of ANB speculative, as is the assumption of no change, but considering only a small number of changes at a time, when in fact many of the determinants have changed, can give misleading estimates of the differences in ANB among fisheries and seasons. Therefore, with few exceptions, such speculations will be left to the reader. However, if at its April 1993 meeting, the Council identifies specific sets of changes in the determinants of ANB that it would like to have considered, the resulting estimates of ANB could be added to this draft report before it is released for public review.

Some of the conclusions that can be drawn form the estimates of ANB and its components are listed below. These conclusions are based both on variable cost model 2 and on the higher estimates of the prohibited species bycatch costs. The higher estimates attempt to account for both the immediate and subsequent adjustments to catch quotas in the fisheries that target on the species that are prohibited species in the groundfish fisheries. The lower estimates only account for the immediate adjustments. There are two reasons why the conclusions listed below are based on variable cost model 2 (Table 4.1). First, for the trawl and pot fleets, model 2 uses the variable cost data provided by the industry, not the plus and minus 25 percent data used to generate a range; and for the longline fleet, model 2 uses what is thought to be the best variable cost data provided for that fleet. Second, a comparison using all three models would be much more difficult to present and to understand. However, because the estimates of ANB and its components are presented in Table 2.3 and Figures 2.4 - 2.7 for all three models, comparisons can be made using all the models or any desired combination of the models.

1. For the cod longline fishery, each 1,000 mt of cod that is transferred from the first season to the third would decrease net benefits by $188,000 or by $228,000 based on 1991 and 1992 data. This unexpected result is explained by the following: a decrease in the ratio of product weight to catch weight between the first and third seasons in both years (Table D3); the increase in variable cost between the first and third seasons both years (Table 1); and in 1992 a decrease in the average price of the principal products between the first and third seasons (Table D2) due to the concentration of third season catch during September.

2. For each 1,000 mt of catch that is taken from the first season trawl fishery and given to the first season longline fishery, net benefits would be reduced by $85,000 or by $100,000 based on 1991 and 1992 data.

3. For each 1,000 mt of catch that is taken from the first season trawl fishery and given to the third season longline fishery, net benefits would be reduced by $273,000 or by $328,000 based on 1991 and 1992 data.

4. Conclusions 2 and 3 would not be changed substantially even if it is assumed that halibut bycatch mortality will be eliminated in the cod longline fishery.

5. For each 1,000 mt of catch that is taken from the first season trawl fishery and given to the first season pot fishery, net benefits would be increased by $212,000 based on 1992 data. In 1991, there was not sufficient catch in the pot fishery the first season to allow a meaningful comparison.

Although these comparisons in ANB can be made among cod fisheries and season, it is important to remember that within each fishery and season there are substantial differences in ANBs among individual operations. Therefore, even though the ANB for one fishery and season may be substantially greater than that of a different fishery and season, typically some of the individual operations in the latter fishery and season will have ANBs that are substantially greater than the ANBs of some of the individual operations in the former fishery and season. This means that reallocating cod on the basis of gear and/or season alone will not be optimal with respect to ANB for the cod fishery as a whole.

An additional problem is that the determinants of ANB for each fishery and season will change and those changes and their effects on ANB are very difficult to predict accurately. This means that it is much more difficult to predict whether a specific change in the distribution of the cod TAC among fisheries and seasons will increase or decrease net national benefits than it is to estimate what the net benefits were for a recent distribution.

The problem of ANBs overlapping among individual operations for different fisheries and seasons and the problem of not being able to predict many of the changes in ANB by fishery and season generally are addressed much more successfully by the market mechanism than by an allocation board or committee.

Table 4.1 Estimates of net benefit per mt of cod catch (ANB) and its components by cod fishery, season, and year, based on variable cost model 2 for each fishery, 1991-92.

	1991 Jan-May	1991 Jun-Aug	1991 Sep-Dec	1992 Jan-May	1992 Jun-Aug	1992 Sep-Dec	1991 Jan-Dec	1992 Jan-Dec
Longline								
Gross	845	784	722	777	704	772	784	749
Var. cost	509	548	552	483	560	676	535	524
Hal. low	5	15	15	9	35	23	11	20
Hal. high	5	16	16	10	39	25	12	22
Oth. proh	0	0	0	0	0	0	0	0
Gf. cost	11	40	21	11	21	27	23	16
ANB w/lo	321	181	134	273	88	46	215	190
ANB w/hi	321	179	133	272	84	44	214	188
Pot								
Gross	.	671	749	1,017	658	768	710	765
Var. cost	.	336	432	431	513	907	384	507
Hal. low	.	1	0	1	0	1	1	1
Hal. high	.	1	0	1	0	1	1	1
Oth. proh	.	1	5	1	2	1	3	1
Gf. cost	.	1	1	1	4	4	1	3
ANB w/lo	.	333	315	585	141	-143	324	255
ANB w/hi	.	332	311	584	140	-144	321	253
Trawl								
Gross	1,194	.	.	1,139	.	.	1,194	1,139
Var. cost	601	.	.	577	.	.	601	577
Hal. low	25	.	.	29	.	.	25	29
Hal. high	42	.	.	50	.	.	42	50
Oth. proh	5	.	.	4	.	.	5	4
Gf. cost	140	.	.	136	.	.	140	136
ANB w/lo	428	.	.	397	.	.	428	397
ANB w/hi	406	.	.	372	.	.	406	372

Note: All figures are dollars per mt of cod catch. ANB w/lo and ANB w/hi, respectively, are estimates of ANB with the lower and higher estimates of the bycatch cost of prohibited species per mt of cod catch. There was not sufficient catch in the trawl fishery the second and third seasons of 1991 and 1992 or in the pot fishery the first season of 1991 to provide meaningful estimates of ANB.

4.1.9 Expected distribution effects

The alternatives being considered include explicit and/or implicit redistributions of cod catch among the three cod fisheries. An alternative that provides more cod for one fishery at the expense of another tends to benefit participants in the former at the expense of participants in the latter. If there had been no cod trawl fishery in 1992, the loss in product value to the trawl fishery as a whole would have been $54.3 million. The comparable estimates are $72.8 million for the cod longline fishery and $9.8 million for the cod pot fishery. It is not clear how much of this product value could be made up by increased participation in other fisheries.

The fact that the 2.0 million mt OY for the BSAI groundfish fishery apparently was taken or exceeded in both 1991 and 1992 suggests that the redeployment of effort, that will result from management action that directly or indirectly reduces the amount of cod taken in one cod fishery, will be competitive or displacing redeployment, as opposed to redeployment that increases catch in other fisheries. For example, the elimination of the cod trawl fishery would be expected to result in some former participants in the cod trawl fishery entering other trawl fisheries and the cod longline and pot fisheries or increasing their participation in those fisheries. This will decrease the loss they would otherwise bear, impose a loss on current participants in other trawl fisheries, and decrease the gain to the current participants in the cod longline and pot fisheries.

4.1.10 Expected effects on consumers

Due to the relatively low importance of BSAI cod in the budgets of most consumers and due to the availability of substitutes for BSAI cod, none of the alternatives is expected to have a measurable or significant effect on domestic consumers with respect to the amount of food available or the price of that food.

4.1.11 Expected effects on competitiveness of the U.S. fishing industry

An explicit or implicit allocation of cod to operations that are currently less profitable or that could become unprofitable if market or regulatory conditions deteriorate would tend to decrease the competitiveness of the U.S. fishing industry in domestic and world markets. The difficulty in determining which cod fishery will tend to be the most competitive and the fact that within each cod fishery there is likely to be a range of very unprofitable to very profitable operations increase the probability that the allocation decision made will decrease competitiveness. Often the use of the market mechanism to allocate resources will increase the competitiveness of the domestic industries. However, as stated in Chapter 1, this is not one of the options being considered to allocate the cod TAC among cod fisheries and cod fishermen.

4.1.12 Expected effects on reporting, management, enforcement, and information costs

4.2 Other Aspects of the Alternatives

A variety of additional issues or aspects of the alternatives are discussed below. With respect to some of the issues, there is not sufficient information to do more than note the potential of a beneficial or adverse effect and perhaps provide some idea concerning the probability that the potential effect will occur. Such information or lack of information is difficult to deal with. It typically would be a mistake either to assume that such effects will occur or to ignore them.

4.2.1 Attainment of OY with existing PSC limits

Prior to the use of blend estimates of catch, it appeared that the BSAI groundfish OY had not been attained. For 1991 and 1992, the blend estimates of total catch for the TAC species in the BSAI groundfish fisheries are 2.2 million mt and 2.0 million mt, respectively. Therefore, the 2.0 million mt OY was taken in both years. Based on 1991 gear-specific and target species-specific discard mortality rates for the BSAI trawl fisheries, 1991 and 1992 bycatch rates, and 1991 and 1992 blend estimates of catch, the estimates of halibut bycatch mortality in the BSAI groundfish trawl fisheries are 4,600 mt for 1991 and 3,849 for 1992. Given that the current halibut bycatch mortality limit is 3,775 mt, it would appear that the OY can be taken without either increasing the halibut PSC limit for the trawl fishery or without decreasing the cod trawl fishery's halibut PSC allowance and cod catch.

The ability to take the 2.0 million mt OY approximately within the halibut PSC limits for the trawl and longline fisheries does at least three things. It eliminates the potential benefit of increasing the percent of the OY that can be taken with the existing halibut PSC limit by decreasing catch in the cod trawl fishery. It indicates that the appropriate measure of the cost of halibut bycatch is in terms of foregone catch and benefits in the halibut fishery, not foregone catch and benefits in other groundfish trawl fisheries (See Section 2.2.13 and Appendix D). And because it indicates that groundfish catch will be limited by the OY rather than by the PSC limits, it increases the potential for implementing a more efficient and comprehensive halibut bycatch management regime. In terms of halibut bycatch management, this decreases the potential benefits of the alternatives to the status quo that are being considered in Amendment 24.

4.2.2 Differences in the quantity and quality of biological data from the cod fisheries

Some have suggested that it is far easier to gather catch, discard, and prohibited species bycatch data on longliners than on trawlers and that the greater temporal distribution of catch in the longline cod fishery provides better biological data for the assessment of the status of the cod resource. Both issues are discussed in this section.

The methods employed by observers to obtain total catch, discard, and prohibited species bycatch data on trawlers and longliners are very different. However, the reliability of the resulting data is dependent upon many factors from the cooperation of the crew, to the set-up of the vessel and the abilities of the observer involved. The following are the methods used by observers to obtain the information in question on longliners and catcher/processors followed by an evaluation of the reliability of the data.

There are two methods used to obtain total catch weights on longliners. The first is to extrapolate the observer's sample data to the set and the second is to back calculate the production figures to the retained catch and add in the amount discarded. The amount discarded is calculated using the observer's sample data. In most cases, species the vessel does not process are dropped-off by the rollerman or landed and set aside for the observer. In either case the observer is able to count and weigh, or apply average weights to, each discard species. The only time quantifying discards becomes a problem is when the vessel discards target species in the factory. On many vessels it is impossible for the observer to simultaneously monitor the line and the discard chute. The most frequently encountered prohibited species on a longliner is Pacific halibut. Observers are able to get reliable data on the number of halibut observed. However, this species is rarely landed requiring observers to estimate weights and may have to forego viability sampling in some situations.

Observers on catcher/processors calculate total catch in one of two ways; they either utilize a volumetric measurement of the codend or fish bin, or they back-calculate from production figures and add in the discards. Quantifying the amount of discards can be very difficult. Because there are so many factors

that determine what is discarded, it may appear that there is not necessarily any rhyme or reason to the way a vessel discards catch. For instance the crew may discard some of the pollock less than 26 cm, but not all; or they may fill their hold with part of a codend, and discard the remainder regardless of fish size. Another common scenario is that, due to the number of crew available to sort, just a portion of a given species may be discarded; or a certain species may be discarded from one haul but not the next. With so many factors influencing discards, it can be very difficult to determine, let alone quantify, the discards on catcher/processors. With few exceptions observers on catcher/processors can obtain numbers, lengths, and weights of all prohibited species. They are also able to determine viability of the halibut in their samples.

If total catch is calculated using production figures, the limited number of species and products makes back-calculating from production figures a simpler process on longliners. The alternate methods of calculating total catch, sample data (longliners) and volumetric measurements (catcher/processors) are more comparable. The reliability of the longline data is dependent upon the observer's ability to obtain representative average weights for all species in the sample, while that of the catcher/processor is dependent on the observer's ability to determine a bin or codend volume and density. Assuming you have observers of equal experience and ability either method of estimating catch size should produce reliable data. As described above estimating discards on longliners is also a simpler process, and should provide more credible data. However, it should also be remembered that observers have obtained discard figures with little or no trouble from some catcher/processors.

More prohibited species data are obtained consistently from catcher/processors than from longliners. The majority of longline crews are reluctant to bring halibut on board precluding observers from getting lengths, weights, or viability data.

In general, sampling on longliners is a more straight-forward and simpler process which may result in more reliable data. However, it should be remembered that reliability of data is not something we can gauge. We assume that simpler and less variable the sampling procedures results in more reliable data. The other factor that effects data credibility is the experience and ability of the observer involved. Whereas a good observer will probably do a credible job on any vessel a less experienced or marginal observer will probably obtain more reliable data on a longliner.

Maintaining a year-round fishery could have a beneficial impact on the stock assessment process by providing data on intra-annual growth and other life history processes and by eliminating the need to specify the additional model structure that is currently required to account for intra-annual patterns of effort deployment. However, because cod is taken in other fisheries as bycatch during much of the year, and because the required samples can be collected from the current non-trawl cod fishery, the biological sampling issue does not provide a justification for increasing the proportion of the TAC taken with non-trawl gear.

In summary, differences in the quantity and quality of biological data from the cod fisheries do not appear to provide much justification for favoring a specific allocation of the cod TAC among the cod fisheries and/or among seasons.

4.2.3 Gear conflicts and vessel safety

A reallocation of cod to the cod longline or pot fishery will tend to increase gear conflicts within the groundfish fishery because, typically, there are fewer gear conflicts among trawlers than they are either among non-trawlers or between trawlers and non-trawlers. A decrease in the size of the trawl cod fishery could decrease conflicts between the cod trawl fisheries and fixed gear fisheries for groundfish and crab. An increase in effort in the cod pot fishery could increase gear conflicts for all three cod fisheries and

other fisheries as well

Because the potential for gear conflicts can be reduced substantially by better communications among fishermen and by other means, gear conflicts are not expected to have an important effect on the relative merits of allocation among the three cod fisheries. Although exclusive time/area openings by cod fishery could be used to eliminate gear conflicts, it is not clear that such a remedy would be needed. This solution is beyond the scope of the alternatives being considered.

Gear-specific differences in vessel safety have not been identified. However, season-specific differences in vessel safety are more apparent. The wind speed and wave height data presented in Tables A40-A42 indicate that November through January is often the most hazardous period for fishing in the BSAI.

4.2.4 Effects on other fisheries

A change in the distribution of cod catch among the three cod fisheries and/or seasons will affect both the periods of time which the vessels that participate in the BSAI cod fisheries will have available to participate in other fisheries and the incentives these vessels will have to participate in other fisheries. Although the responses of each fleet are difficult to predict, some possible effects can be identified.

Some of the vessels that participate in the BSAI cod fishery have the option to also participate in the GOA cod fishery. As a result of Amendment 23 to the GOA FMP (i.e., the Inshore/Offshore allocation), this option is limited to catcher boats and very small catcher/processors. Therefore, an alternative that reduced the catch available to one of the BSAI cod fisheries would tend to result in increased competition in the GOA by some vessels in that BSAI cod fishery.

Other potential effects on other fisheries will be identified by the AP, SSC, and Council when this report is reviewed in April and by the others after the draft is released for public review.

4.2.5 Fairness and equity

The determination of what is fair is very subjective. The Council has often used the historical distribution of catch to define what is fair and has favored the traditional fishery. For example, the principal objective of the Inshore/Offshore allocation amendments was to prevent preemption of one group of participants by another. Alternatively, it can be argued that it is not fair to the Nation as a whole to have an allocation that does not maximize the benefits that the Nation can receive from its cod resources or from all resources into which cod is an input. These two definitions of what is fair often have different implications concerning what allocation is fair. The latter would include environmental benefits and costs to the extent they can be measured; therefore, it would include what some have referred to as being fair to the ecosystem. Because the rate and magnitude of change from the current distribution clearly affect adjustment costs, the historical distribution of catch is of importance in terms of both concepts of equity.

4.2.6 Difficulties associated with changing the fishing year for Pacific cod to September-August

If it is determined that there are sufficient benefits to the cod fisheries to change the cod fishing year to September-August, two issues need to be resolved before a final decision can be made concerning the merits of such a change. The first issue has to do with allowing the cod TAC and the cod fisheries' PSC allowances to be exceeded by perhaps more than 50 percent for the calendar year in which the transition would take place to the September-August fishing year. This issue is discussed in Section 3.8. The other issue is the scheduling changes that would be necessary to have a September - August fishing year. This latter issue is the topic of this section.

Under the status quo alternative, 25 percent of the initial TAC proposed for Pacific cod during the annual specification process is available for harvest at the beginning of each fishing on an interim basis. The interim TAC subsequently is superseded by the final initial TAC, which becomes effective normally by late January or February of each fishing year. Under existing regulations, directed fishing for Pacific cod with gear other than trawl gear commences on January 1 of each year; fishing with trawl gear is prohibited until January 20.

Under one alternative, the FMP would be amended to establish a September 1-August 31 fishing year for Pacific cod. Two options are presented to implement this alternative. Option 1 would revise the annual specification process so that final initial TAC amounts for Pacific cod and associated PSC bycatch allowances would be available for harvest on September 1 of each year. Option 2 would not significantly revise the annual specification process, but would allow for the harvest of a subsequent year's interim TAC starting on September 1 of the current year.

Option 1 would require that final ABC, TAC, and PSC bycatch allowances be published in the Federal Register by September 1 of each year. To allow for this schedule under existing procedures for annual establishment of fishery specifications, the Council would be required to provide proposed recommendations to NMFS by May of each year for publication in the Federal Register for pubic review and comment. Similarly, the Council would be required to provide final recommendations to NMFS by July or early August. This schedule for the annual establishment of Pacific cod TAC and associated bycatch specifications could require that a separate Stock Assessment and Fishery Evaluation (SAFE) report be prepared for Pacific cod to support proposed and final recommendations by the Council.

Under Option 1, directed fishing for Pacific cod would commence on September 1 and continue until the directed fishing allowance is reached subject to bycatch and other regulatory constraints (e.g., fishing with trawl gear currently is prohibited from January 1 until January 20 of each year). If the fishery were allowed to continue without interruption until the directed fishery allowance was harvested, target operations for Pacific cod likely would extend into the following calendar year, particularly if gear specific allocations of TAC are implemented to reduce fishing competition for cod among the trawl, hook-and-line, and pot gear fleets. Notwithstanding the advantages this option may present with respect to benefits to the cod fisheries, the implementation of this option could be administratively expensive.

Analyses of resource assessment survey data or other stock assessment information typically are not available before November of each year. A May-August specification process for Pacific cod, therefore would be based on status of stock information that is 6-12 months old. Although this schedule may not pose concern from a stock management perspective, questions exist whether adequate information would be available to establish specifications for a Pacific cod TAC and associated PSC allowances separate from other groundfish TAC and bycatch considerations that would continue to be developed during a September-December specification process. Furthermore, new information developed during this process may induce industry or other special interest groups to argue for inseason adjustments of Pacific cod TAC or associated PSC bycatch allowances.

In summary, additional management and administrative costs under this option include those associated with (1) BSAI Plan Team preparation of a separate SAFE report or other status of stock document to support Council recommendations for Pacific cod TAC during a May-August TAC specification process; (2) Council consideration of proposed and final Pacific cod TAC specifications would require that this agenda item be addressed within a time schedule that would allow for a September 1 starting date of the Pacific cod fishery, including the possibility of a separate Council meeting in early August of each year; (3) additional NMFS staff time to prepare, review, and approve separate TAC and bycatch specifications for the Pacific cod fishery and any associated NEPA and ESA documentation and determinations, and develop separate monitoring programs for this fishery; and, (4) additional administrative and management

costs associated with mid-season adjustments or respecification of Pacific cod TAC and PSC specifications if new information became available during the September-December specification process for other groundfish species that warrant such inseason revisions.

Option 2 for a September 1 opening date of the Pacific cod fishery essentially would maintain the existing September-December TAC specification process for Pacific cod, except that the framework process for establishing interim TAC amounts would be revised. Under this option, the interim TAC for an upcoming fishing year would be based on an established percentage of the present year's TAC and be made available for harvest on September 1. The existing FMP establishes interim TACs at 25 percent of the TACs proposed by the Council during its annual September meeting. The FMP could be amended, however, to authorize an adjustment of this percentage by regulatory amendment to allow for a larger or smaller percentage of the proposed Pacific cod TAC to be available to the fishery on September 1. Once the interim TAC amount was harvested, the Pacific cod fisheries would be closed until the final TAC specifications were effective, typically by late January or February of each year.

Option 2 would involve fewer administrative and management costs relative to the option 1 because a separate TAC specification process would not be required for Pacific cod. Additional costs could be incurred by the fishing industry because target fishing for Pacific cod would be prohibited from the time the interim TAC or associated bycatch allowances were taken until final TAC and bycatch specifications were effective. If the interim TAC were maintained at 25 percent of the present year's TAC (about 41,000 mt based on the 1993 TAC), and assuming a weekly catch of about 7,000 mt per week (based on weekly catch of Pacific cod in all fisheries in January and February, 1993), the interim fishery could last 6-7 weeks before the interim TAC is reached and the Pacific cod fisheries are closed until final TAC specifications are effective.

4.2.7 Options for changing the allocation of the cod TAC among seasons once the initial allocation has been established

One alternative would amend the FMP to establish season apportionments of the Pacific cod TAC. Under this alternative, there are three options concerning the Council/NMFS process for changing the season apportionments once they have been established. They are: (1) an FMP amendment, (2) a regulatory amendment, and (3) a framework that could be used annually. The last option would be similar to the process currently followed by the Council for setting seasonal allowances for the pollock roe and non-roe seasons.

There are two major problems with a framework process that uses the pre-season TAC specification process. First, NMFS simply cannot ever complete the filing of the final specifications before the beginning of the year. The timing is wrong (too close to the beginning of the fishing year) and the more tasks the Council loads into the process, the less likely NMFS is going to be able to get the final specs filed anytime close to the beginning of the year. The second problem is more substantive, the specification process is so rushed that it is unlikely to result in carefully reasoned allocation decisions or perhaps even conservation decisions. There is doubt whether the spec process will allow NMFS time to ensure that it is meeting the requirements of other applicable laws, such as, the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA) and the National Environmental Policy Act (NEPA). It is not known if NOAA General Counsel would flatly say as a matter of law that apportioning the Pacific cod TAC by seasons annually in the spec process is illegal. However, NOAA General Counsel probably would advise the Council against overloading the September-to-December spec process with even more substantive determinations that must be made considering that there are already more determinations required during this time period than can be accomplished with existing staff and time constraints before the beginning of the year. The so-called September-to-December process really is a November-to-February or March process, and loading more into it will delay things even more.

A framework for cod similar to that for apportioning pollock between the "A" and "B" seasons would tend to have substantially greater allocation effects than does the pollock framework. This is because the three cod fisheries are much less homogeneous than are the pollock fisheries and, therefore, the apportionments among seasons can be used to a greater extent both to allocate the cod TAC among the three cod fisheries and to determine the benefits each fishery will receive from it cod harvest.

4.2.8 Benefits of explicit allocations by fishery with respect to establishing optimal seasons for each fishery

In the absence of an explicit allocation of cod by fishery, the catch in each fishery is determined by: (1) the cod TAC; (2) the amount of cod that is taken in the other cod fisheries before they are closed by their halibut PSC limits; (3) the amount of cod that is expected to be taken as bycatch in other fisheries (principally non-cod trawl fisheries); (4) its own halibut PSC limit; and, particularly if the PSC limits do not constrain catch, (5) the pace at which cod is harvested in each fishery.

If each cod fishery had an explicit share of the cod TAC, a fishing season could be set for each fishery that would allow it to maximize the benefits it can derive from that level of catch. The optimal season for each fishery, which would be determined by biological, environmental, regulatory, and market conditions, could differ substantially from the current season on a yearly basis. In the absence of explicit allocations by fishery, common seasons are required and agreement on optimal common seasons is expected to be very difficult. This was demonstrated in late 1992 when the Council was unable to agree on a season change for 1993.

Most cod products are frozen and can be stored for up to a year without a significant decrease in product quality (MacCallum et. al). This has two important effects on the optimal season. First, the seasonality of demand principally affects the optimal season through storage and interest costs. Second, consistency of catch throughout the year is not required to have a consistent and predictable monthly supply of cod for specific markets.

4.2.9 Allocating the TAC by season and changing the cod fishing year to September - August

One alternative is to allocate the TAC by season and also change the cod fishing year to September - August. If it is determined that seasonal apportionments will be used, it would appear that the benefits of changing the fishing year would be eliminated for the most part and without some of the difficulties and costs associated with changing the fishing year.

There are two exceptions to this. If the objective is to assure that catch during September - December is not limited by catch during the remainder of the year, both changes would be necessary. This is because with a January-December fishing year, catch in excess of the apportionments for the first and second seasons together would reduce the amount of the TAC actually available in the third season. There may also be strategic political or negotiation reasons for a group that prefers to fish in September - December to want both changes.

The potential problem of excess catch in the first two seasons and the resulting decrease in allowable catch during the third season is reduced substantially for two reasons. First, as noted in Item 1, the NMFS is expected to be able to monitor the cod TAC and its apportionments successfully. Second, because the apportionment for the second season is expected to be much smaller than that for the first or third season, excess catch in the first season can be adjusted for by reducing second season catch and the probability of substantial excess catch in the second season is lower. Therefore, if the objective is to assure that at least a fixed percent of the TAC is available the third season (September-December), seasonal apportionments probably are sufficient. If the concern is that any apportionment that is not used

the first season (January-May) should be taken in the third season (September - December), not in the second season (June-August), the rollover rules can be written to address this concern.

It is not clear that also changing the fishing year would be an advantage to one or more of the cod fisheries in terms of the amount of the cod TAC that is reserved for cod bycatch in other fisheries. However, the fishing year change could increase the probability that cod would become a prohibited species in other groundfish fisheries in the June-August.

4.3 Social and economic effects of the preferred alternative

The principal benefits from the preferred alternative are in terms of the stability it provides and the ability to shift longline catch from the second to third season, if the longline and pot gear apportionment is not all taken during the first season. This statement is supported by the following 14 points which summarize information presented in this chapter of the EA/RIR/IRFA. That information is based on data and analyses contained in Chapters 2 and 3 and Appendices A-I.

1. Expected Effects on Coastal Community Stability

The preferred alternative is not expected to result in a sufficiently large change in the distribution of catch by fishery or season to have a measurable effect on the stability of coastal communities. However, by fixing the allocation of cod between the trawl and non-trawl fisheries, the preferred alternative eliminates one source of uncertainty. This should be of some benefit with respect to community stability.

2. Historical Use of the Cod Fishery

As noted above, the preferred alternative will fix the distribution of cod between the trawl and non-trawl fisheries at about the average for the last few years.

3. Current Dependence on the Cod Fishery

Because the preferred alternative will fix the distribution of cod between the trawl and non-trawl fisheries at about the average for the last few years, the preferred alternative will tend to allow each cod fishery to maintain its current level of dependence.

4. Expected Effects on Economic Benefits to the Nation

Given that the preferred alternative is not expected to result in a significant change in the distribution of cod catch by fishery and given that the differences in the estimates of net benefits per mt of cod catch by fishery are not significantly different, the preferred alternative is expected principally to provide benefits as the result of increased stability and decreased uncertainty. The preferred alternative will also provide benefits by allowing a transfer of longline catch from the second to the third season. However, the latter benefit is expected to be quite small because the fixed gear fishery is expected to request and take most or perhaps all of its annual apportionment during the first season.

5. Expected Distribution Effects

The preferred alternative will maintain the recent distribution of catch between the trawl and non-trawl fisheries.

6. Expected Effects on Consumers

The preferred alternative is not expected to have an effect on domestic consumers with respect to the amount of food available or the price of that food because of (1) the relatively low importance of BSAI cod in the budgets of most households, (2) the availability of substitutes for BSAI cod, and (3) the minimal effect the preferred alternative is expected to have on the distribution of cod catch by fishery or season.

7. Expected Effects on Competitiveness of the U.S. Fishing Industry

The preferred alternative is expected to have too small of an effect on the distribution of catch to have a measurable effect the competitiveness of the U.S. fishing industry in domestic and world markets. However, by fixing the allocation of cod between the trawl and non-trawl fisheries, the preferred alternative eliminates one source of uncertainty. This should be of some benefit with respect to meeting business plans and being competitive in international markets.

8. Expected Effects on Reporting, Management, Enforcement, and Information Costs

The preferred alternative is not expected to have an important effect on reporting, management, enforcement, and information costs. The annual determination of the seasonal apportionments will require some time by the Council and NMFS. However, because the allocation of cod between trawl, longline and pot, and jig gear has been set, the process for apportioning the trawl fishery halibut PSC limit among trawl fisheries should be less contentious and less costly. There will be a small increase in the cost of monitoring the cod TAC and implementing closures because there will be separate quotas and closures by gear group. The net effect is expected to be a small increase in management costs.

9. Attainment of OY with Existing PSC Limits

The preferred alternative is not expected to have a significant effect on the ability of the groundfish fishery to take the 2.0 million mt OY approximately within the halibut PSC limits for the groundfish fishery.

10. Differences in the Quantity and Quality of Biological Data from the Cod Fisheries

The preferred alternative is not expected to change the quantity and quality of biological data from the cod fisheries.

11. Gear Conflicts and Vessel Safety

The preferred alternative is not expected to have a large enough effect on the distribution of catch by gear or season to affect gear conflicts or vessel safety.

12. Effects on Other Fisheries

The preferred alternative is not expected to have a large enough effect on the distribution of catch by gear or season to affect other fisheries significantly.

13. Fairness and Equity

The determination of what is fair is very subjective. The Council has often used the historical distribution of catch to define what is fair and has favored the traditional fishery. For example, the principal objective of the Inshore/Offshore allocation amendments was to prevent preemption of one group of participants by another. Alternatively, it can be argued that it is not fair to the Nation as a whole to have

an allocation that does not maximize the benefits that the Nation can receive from its cod resources or from all resources into which cod is an input. These two definitions of what is fair often have different implications concerning what allocation is fair. The latter would include environmental benefits and costs to the extent they can be measured; therefore, it would include what some have referred to as being fair to the ecosystem. Because the rate and magnitude of change from the current distribution clearly affect adjustment costs, the historical distribution of catch is of importance in terms of both concepts of equity.

The differences by gear in estimated net benefits per mt of cod catch are not substantial enough to justify a change in the distribution of catch among gear groups. Therefore, the preferred alternative, that approximately maintains the current distribution, is equitable in terms of both standards of equity.

14. Options for Changing the Allocation of the Cod TAC Among Seasons Once the Initial Allocation Has Been Established

By limiting the framework authority to apportion seasonally its portion of the cod TAC to the longline and pot gear fishery, the preferred alternative makes the annual process much less contentious than if this authority also were created for trawl gear. However, it would have been even less contentious if the longline and pot gear apportionment had been split between longline and pot gear.

In summary, the preferred alternative meets the Council's objective to provide a measure of stability to the fishery while allowing various components of the industry to optimize their utilization of the resource. By doing this with only a minimal increase in management costs, the preferred alternative is expected to provide net benefits to the nation.

5.0 EFFECTS ON ENDANGERED AND THREATENED SPECIES AND ON THE ALASKA COASTAL ZONE

Fishing activities conducted under any of the alternatives considered would not affect any endangered or threatened species listed under the Endangered Species Act in any manner not already considered in (1) the formal consultations conducted on the BSAI and GOA groundfish fisheries (both dated April 19, 1991), the 1992 BSAI total allowable catch specifications (January 21, 1992), and Amendment 18 to the BSAI FMP (March 4, 1992); and (2) the informal consultations conducted regarding the impacts of the 1992 GOA total allowable catch specifications (December 23, 1991), the 1993 BSAI and GOA total allowable catch specifications on Steller sea lions (January 20, 1993, and January 22, 1993, respectively), the impacts of the 1993 BSAI and GOA groundfish fisheries on listed species of salmon (April 21, 1993) and listed species of seabirds (U.S. Fish and Wildlife Service, February 1, 1993). Therefore, no further consultation, pursuant to section 7 of the Endangered Species Act, is required for implementation of any of the alternatives, including the proposed action.

Each of the alternatives discussed above would be conducted in a manner consistent, to the maximum extent practicable, with the Alaska Coastal Zone Management Program within the meaning of section 307)c)(1) of the Coastal Zone Management Act of 1972 and its implementing regulations.

6.0 OTHER EXECUTIVE ORDER 12866 REQUIREMENTS

Executive Order 12866 requires that the following issues be considered.

1. Will the amendment have an annual effect on the economy of $100 million or more?

2. Will the amendment have an adverse effect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety?

3. Will the amendment have an adverse effect on a material way on State, local or tribal governments or communities?

Regulations increase some costs, decrease others, and cause a redistribution of costs and benefits. The alternatives are expected to have different effects both on net benefits to the Nation and on the distribution of those benefits. None of the alternatives are expected to have an annual effect of $100 million.

None of the alternatives are expected to lead to a significant change in the prices paid by consumers, local governments, or geographic regions because the total supply of fishery products is not expected to be affected measurably. Costs of management and enforcement are not anticipated to change substantially.

Some of the alternatives being considered could have adverse effects on competition, employment, investment, productivity, innovation, or on the ability of U.S.-based enterprises to compete with foreign enterprises in domestic or export markets.

None of the alternatives are expected to have any adverse effects on State, local or tribal governments or communities.

7.0 IMPACT OF THE AMENDMENT RELATIVE TO THE REGULATORY FLEXIBILITY ACT

The Regulatory Flexibility Act (RFA) requires that impacts of regulatory measures imposed on small entities (i.e., small businesses, small organizations, and small governmental jurisdictions with limited resources) be examined to determine whether a substantial number of such small entities will be significantly impacted by these measures. Fishing vessels are considered to be small businesses. Fewer than 300 vessels are expected to participate in the BSAI cod fisheries in 1993 and beyond. Each alternative is expected to benefit some of these small businesses and have adverse effects for others.

8.0 FINDING OF NO SIGNIFICANT IMPACT

For the reasons discussed above, implementation of the none of the alternatives being considered would significantly affect the quality of the human environment, and the preparation of an environmental impact statement on the final action is not required under section 102(2)(c) of the National Environmental Policy Act or its implementing regulations.

Date:

____

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APPENDICES A - I

ENVIRONMENTAL ASSESSMENT/REGULATORY IMPACT REVIEW/ INITIAL REGULATORY FLEXIBILITY ANALYSIS OF ALTERNATIVES TO ALLOCATE THE PACIFIC COD TOTAL ALLOWABLE CATCH BY GEAR AND/OR DIRECTLY CHANGE THE SEASONALITY OF THE COD FISHERIES

AMENDMENT 24 TO THE FISHERY MANAGEMENT PLAN FOR THE GROUNDFISH FISHERY OF THE BERING SEA AND ALEUTIAN ISLANDS AREA

Prepared by
National Marine Fisheries Service,
Seattle, Washington

October 5, 1993

NOTE: The EA/RIR/IRFA text is in a separate volume.

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APPENDIX A

PACIFIC COD CATCH AND THE PACIFIC COD FISHERIES

Prepared by
National Marine Fisheries Service,
Seattle, Washington

October 5, 1993

Table A1 Annual BSAI Pacific cod catch, TAC, biomass, and catch as a percent of biomass, 1981-92 (metric tons).

Year	Total catch	% change from previous year	TAC	% of TAC taken	Biomass estimate	Catch as a % of biomass
1981	62,395		78,700	79.3%	1,011,383	6.2%
1982	64,944	4.1%	78,700	82.5%	1,199,875	5.4%
1983	97,278	49.8%	120,000	81.1%	1,285,638	7.6%
1984	127,735	31.3%	210,000	60.8%	1,269,541	10.1%
1985	144,272	12.9%	220,000	65.6%	1,313,957	11.0%
1986	137,869	-4.4%	229,000	60.2%	1,241,831	11.1%
1987	157,611	14.3%	280,000	56.3%	1,253,152	12.6%
1988	197,054	25.0%	200,000	98.5%	1,199,335	16.4%
1989	168,382	-14.6%	226,079	74.5%	1,045,358	16.1%
1990	175,535	4.2%	199,975	87.8%	891,171	19.7%
1991	218,064	24.2%	194,650	112.0%	794,191	27.5%
1992	205,326	-5.8%	182,000	112.8%	717,532	28.6%

Sources: The estimates of foreign and joint venture catch for all years and the estimates of domestic catch for 1981-89 are from PacFIN. The 1990 estimates of domestic catch are from the weekly processor report data set. The 1991-92 estimates of catch are blend estimates based on both observer and weekly processor data sets. With the exception of the 1981-89 domestic data, these data include estimates of discards. These are the sources of all the catch and product weight data in this report.

The biomass estimates are based on annual trawl surveys of the EBS and periodic trawl surveys of the AI area. The AI biomass estimates for the years without surveys are interpolated from the AI survey estimates.

Table A2 Annual BSAI Pacific cod catch by fishery, 1981-92 (metric tons).

Year	Foreign Catch	Foreign Share	Joint Venture Catch	Joint Venture Share	Domestic Catch	Domestic Share
1981	39,113	63%	9,159	15%	14,123	23%
1982	28,174	43%	13,592	21%	23,179	36%
1983	41,506	43%	14,362	15%	41,410	43%
1984	58,510	46%	30,771	24%	38,453	30%
1985	57,177	40%	41,272	29%	45,823	32%
1986	39,860	29%	63,942	46%	34,068	25%
1987	54,746	35%	58,157	37%	44,708	28%
1988	.	.	109,891	56%	87,163	44%
1989	.	.	44,617	26%	123,764	74%
1990	.	.	8,077	5%	167,458	95%
1991	.	.	.	.	218,064	100%
1992	.	.	.	.	205,326	100%

Sources: 1981-90 - PacFIN, 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A3 Annual BSAI Pacific cod catch by gear, 1981-92 (metric tons).

Year	Longline Gear Catch	Longline Gear Share	Pot Gear Catch	Pot Gear Share	Trawl Gear Catch	Trawl Gear Share
1981	6,113	10%	.	.	56,283	90%
1982	3,622	6%	.	.	61,322	94%
1983	6,851	7%	21	0%	90,407	93%
1984	27,453	21%	.	.	100,282	79%
1985	37,621	26%	.	.	106,651	74%
1986	26,611	19%	63	0%	111,196	81%
1987	48,417	31%	89	0%	109,104	69%
1988	2,564	1%	329	0%	194,160	99%
1989	13,952	8%	164	0%	154,265	92%
1990	47,598	27%	1,386	1%	126,413	72%
1991	79,703	37%	6,673	3%	131,688	60%
1992	101,182	49%	13,680	7%	90,272	44%

Sources: 1981-90 - PacFIN, 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A4 Annual distribution of BSAI Pacific cod catch among gear groups by fishery, 1981-92.

Annual distribution (metric tons)

Year	Foreign Longline	Foreign Trawl	Joint Venture Trawl	Domestic Longline	Domestic Pot	Domestic Trawl
1981	6,086	33,027	9,159	27	.	14,097
1982	3,617	24,556	13,592	5	.	23,175
1983	6,847	34,660	14,362	4	21	41,385
1984	27,445	31,065	30,771	8	.	38,445
1985	37,572	19,605	41,272	49	.	45,774
1986	26,563	13,298	63,942	48	63	33,956
1987	47,028	7,718	58,157	1,389	89	43,230
1988	.	.	109,891	2,564	329	84,269
1989	.	.	44,617	13,952	164	109,647
1990	.	.	8,077	47,598	1,386	118,336
1991	.	.	.	79,703	6,673	131,688
1992	.	.	.	101,182	13,680	90,272

Annual percent distribution

Year	Foreign Longline	Foreign Trawl	JV Trawl	Longline	Domestic Pot	Trawl
1981	16%	84%	100%	0%	.	100%
1982	13%	87%	100%	0%	.	100%
1983	16%	84%	100%	0%	0%	100%
1984	47%	53%	100%	0%	.	100%
1985	66%	34%	100%	0%	.	100%
1986	67%	33%	100%	0%	0%	100%
1987	86%	14%	100%	3%	0%	97%
1988	.	.	100%	3%	0%	97%
1989	.	.	100%	11%	0%	89%
1990	.	.	100%	28%	1%	71%
1991	.	.	.	37%	3%	60%
1992	.	.	.	49%	7%	44%

Sources: 1981-90 - PacFIN, 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A5 Closures of the domestic trawl fishery for Pacific Cod in the BSAI, 1990-92.

Year	Area	Date	Cause
1990	1/2H	5/30 - 12/31	PSC - Halibut
	BSAI	6/30 - 12/31	PSC - Halibut
1991	1/2H	2/17 - 3/31	PSC - Halibut
	BSAI	3/08 - 3/31	PSC - Halibut
	1/2H	4/19 - 5/03	PSC - Halibut
	1/2H	5/03 - 12/31	PSC - Halibut
	BSAI	5/08 - 7/01	PSC - Halibut
	BSAI	7/08 - 12/31	PSC - Halibut
1992	1	2/15 - 12/31	PSC - Bairdi crab
	BSAI	2/16 - 3/07	PSC - Halibut
	BSAI	5/6 - 12/31	PSC - Halibut

Source: NMFS Alaska Region.

Table A6 Annual distribution of BSAI Pacific cod catch by seasons, 1981-92 (metric tons).

	Jan-May		Jun-Aug		Sep-Dec	
Year	Catch	%	Catch	%	Catch	%
1981	17,155	27%	17,112	27%	28,129	45%
1982*	19,080	29%	23,757	37%	22,107	34%
1983	44,536	46%	30,762	32%	21,980	23%
1984*	51,021	40%	29,233	23%	47,480	37%
1985	68,884	48%	32,100	22%	43,287	30%
1986	65,546	48%	33,024	24%	39,300	29%
1987	83,164	53%	27,553	17%	46,894	30%
1988	126,366	64%	25,164	13%	45,524	23%
1989*	93,317	55%	28,954	17%	46,111	27%
1990*	113,787	65%	32,720	19%	29,029	17%
1991	140,154	64%	41,318	19%	36,592	17%
1992	132,778	65%	60,095	29%	12,453	6%

Note: These data are for the foreign, joint venture, and domestic fisheries combined.
* - Strong year classes.

Sources: 1981-90 - PacFIN, 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A7 Monthly Pacific cod catch in the BSAI, 1981-92.

Catch in thousands of metric tons

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	2.0	3.2	2.2	2.3	7.5	6.7	4.8	5.6	6.2	7.6	5.5	8.8
1982	1.6	1.3	4.4	7.5	4.3	4.1	11.6	8.0	5.2	4.3	5.6	7.0
1983	3.3	9.8	9.4	11.0	11.0	10.3	10.1	10.4	3.5	3.3	5.3	9.9
1984	2.4	7.6	14.2	21.7	5.2	9.8	9.3	10.1	8.6	8.2	13.0	17.7
1985	3.2	17.9	15.9	14.2	17.7	8.4	12.6	11.1	9.2	12.7	10.9	10.5
1986	2.3	18.1	18.2	15.2	11.7	13.9	9.2	9.9	10.8	10.2	13.1	5.3
1987	7.6	33.0	21.1	11.2	10.3	10.9	11.0	5.6	4.4	15.0	14.9	12.6
1988	20.2	37.1	33.1	27.8	8.1	10.0	8.7	6.5	11.9	14.7	10.5	8.4
1989	28.7	25.2	13.8	15.7	9.9	10.0	10.0	8.9	15.3	10.2	8.7	12.0
1990	21.1	30.0	25.1	17.8	19.8	15.0	7.4	10.4	9.3	8.3	6.4	5.1
1991	23.3	26.5	23.8	51.3	15.1	9.1	13.2	19.1	10.3	9.6	10.3	6.5
1992	16.0	26.6	30.2	43.6	16.4	16.6	25.2	18.3	9.4	1.8	.4	.9

Catch as a percent of annual catch

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	3%	5%	4%	4%	12%	11%	8%	9%	10%	12%	9%	14%
1982	2%	2%	7%	12%	7%	6%	18%	12%	8%	7%	9%	11%
1983	3%	10%	10%	11%	11%	11%	10%	11%	4%	3%	5%	10%
1984	2%	6%	11%	17%	4%	8%	7%	8%	7%	6%	10%	14%
1985	2%	12%	11%	10%	12%	6%	9%	8%	6%	9%	8%	7%
1986	2%	13%	13%	11%	9%	10%	7%	7%	8%	7%	10%	4%
1987	5%	21%	13%	7%	7%	7%	7%	4%	3%	10%	9%	8%
1988	10%	19%	17%	14%	4%	5%	4%	3%	6%	7%	5%	4%
1989	17%	15%	8%	9%	6%	6%	6%	5%	9%	6%	5%	7%
1990	12%	17%	14%	10%	11%	9%	4%	6%	5%	5%	4%	3%
1991	11%	12%	11%	24%	7%	4%	6%	9%	5%	4%	5%	3%
1992	8%	13%	15%	21%	8%	8%	12%	9%	5%	1%	0%	0%

Sources: 1981-90 - PacFIN, 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A8 Seasonal Pacific cod catch in the BSAI by fishery and gear, 1981-92.

Catch in thousands of metric tons

Year	Foreign LGL	Foreign TWL	Foreign Total	JV TWL	JV Total	Domestic LGL	Domestic POT	Domestic TWL	Domestic Total
1981									
Jan-May	1.4	8.8	10.2	2.2	2.2	.0	.	4.8	4.8
Jun-Aug	.7	7.9	8.5	5.3	5.3	.0	.	3.2	3.2
Sep-Dec	4.0	16.4	20.4	1.7	1.7	.	.	6.1	6.1
1982									
Jan-May	.5	5.7	6.3	3.9	3.9	.	.	8.9	8.9
Jun-Aug	.5	6.6	7.1	8.9	8.9	.0	.	7.7	7.7
Sep-Dec	2.5	12.3	14.8	.7	.7	.	.	6.6	6.6
1983									
Jan-May	3.2	10.6	13.8	3.6	3.6	.	.0	27.1	27.2
Jun-Aug	.8	9.1	9.9	10.4	10.4	.0	.	10.5	10.5
Sep-Dec	2.8	15.0	17.8	.4	.4	.0	.	3.8	3.8
1984									
Jan-May	5.3	2.8	8.0	17.2	17.2	.0	.	25.8	25.8
Jun-Aug	2.2	11.8	14.0	11.1	11.1	.0	.	4.2	4.2
Sep-Dec	20.0	16.4	36.5	2.5	2.5	.0	.	8.5	8.5
1985									
Jan-May	13.7	1.2	14.9	17.3	17.3	.	.	36.7	36.7
Jun-Aug	1.7	5.6	7.3	18.4	18.4	.0	.	6.4	6.4
Sep-Dec	22.2	12.8	35.0	5.6	5.6	.0	.	2.7	2.7
1986									
Jan-May	8.9	.2	9.1	30.1	30.1	.0	.1	26.2	26.3
Jun-Aug	.4	4.6	5.0	21.6	21.6	.0	.	6.4	6.4
Sep-Dec	17.2	8.4	25.7	12.2	12.2	.0	.0	1.3	1.4
1987									
Jan-May	20.8	.0	20.8	39.0	39.0	.6	.0	22.7	23.4
Jun-Aug	.2	1.1	1.3	15.6	15.6	.3	.0	10.4	10.7
Sep-Dec	26.0	6.6	32.6	3.6	3.6	.4	.1	10.1	10.6
1988									
Jan-May	.	.	.	94.0	94.0	.2	.1	32.1	32.4
Jun-Aug	.	.	.	8.3	8.3	.5	.1	16.3	16.9
Sep-Dec	.	.	.	7.6	7.6	1.9	.2	35.9	37.9
1989									
Jan-May	.	.	.	34.0	34.0	2.6	.0	56.7	59.3
Jun-Aug	.	.	.	.	.	3.7	.1	25.2	29.0
Sep-Dec	.	.	.	10.6	10.6	7.7	.0	27.8	35.5
1990									
Jan-May	.	.	.	8.1	8.1	13.2	.0	92.4	105.6
Jun-Aug	.	.	.	.	.	16.8	1.0	15.0	32.7
Sep-Dec	.	.	.	.	.	17.7	.4	11.0	29.0
1991									
Jan-May	.	.	.	.	.	28.7	.1	111.4	140.2
Jun-Aug	.	.	.	.	.	21.6	2.9	16.9	41.3
Sep-Dec	.	.	.	.	.	29.4	3.8	3.4	36.6
1992									
Jan-May	.	.	.	.	.	56.4	3.7	72.7	132.7
Jun-Aug	.	.	.	.	.	38.6	9.4	12.0	60.0
Sep-Dec	.	.	.	.	.	6.2	.6	5.6	12.5

Table A8 Continued.

Percent of annual catch

Year	Foreign LGL	Foreign TWL	Foreign Total	JV TWL	JV Total	Domestic LGL	Domestic POT	Domestic TWL	Domestic Total
1981									
Jan-May	23%	27%	26%	24%	24%	97%	.	34%	34%
Jun-Aug	11%	24%	22%	58%	58%	3%	.	23%	23%
Sep-Dec	66%	50%	52%	18%	18%	.	.	43%	43%
1982									
Jan-May	15%	23%	22%	29%	29%	.	.	38%	38%
Jun-Aug	15%	27%	25%	66%	66%	100%	.	33%	33%
Sep-Dec	70%	50%	53%	5%	5%	.	.	28%	28%
1983									
Jan-May	47%	30%	33%	25%	25%	.	100%	66%	66%
Jun-Aug	12%	26%	24%	72%	72%	67%	.	25%	25%
Sep-Dec	41%	43%	43%	3%	3%	33%	.	9%	9%
1984									
Jan-May	19%	9%	14%	56%	56%	25%	.	67%	67%
Jun-Aug	8%	38%	24%	36%	36%	25%	.	11%	11%
Sep-Dec	73%	53%	62%	8%	8%	51%	.	22%	22%
1985									
Jan-May	36%	6%	26%	42%	42%	.	.	80%	80%
Jun-Aug	4%	29%	13%	44%	44%	48%	.	14%	14%
Sep-Dec	59%	65%	61%	14%	14%	52%	.	6%	6%
1986									
Jan-May	33%	2%	23%	47%	47%	0%	98%	77%	77%
Jun-Aug	2%	35%	13%	34%	34%	30%	.	19%	19%
Sep-Dec	65%	63%	64%	19%	19%	70%	2%	4%	4%
1987									
Jan-May	44%	0%	38%	67%	67%	45%	1%	53%	52%
Jun-Aug	0%	15%	2%	27%	27%	25%	1%	24%	24%
Sep-Dec	55%	85%	60%	6%	6%	31%	98%	23%	24%
1988									
Jan-May	.	.	.	86%	86%	7%	28%	38%	37%
Jun-Aug	.	.	.	8%	8%	20%	22%	19%	19%
Sep-Dec	.	.	.	7%	7%	72%	50%	43%	43%
1989									
Jan-May	.	.	.	76%	76%	18%	28%	52%	48%
Jun-Aug	.	.	.	.	.	26%	42%	23%	23%
Sep-Dec	.	.	.	24%	24%	55%	30%	25%	29%
1990									
Jan-May	.	.	.	100%	100%	28%	0%	78%	63%
Jun-Aug	.	.	.	.	.	35%	71%	13%	20%
Sep-Dec	.	.	.	.	.	37%	29%	9%	17%
1991									
Jan-May	.	.	.	.	.	36%	1%	85%	64%
Jun-Aug	.	.	.	.	.	27%	43%	13%	19%
Sep-Dec	.	.	.	.	.	37%	56%	3%	17%
1992									
Jan-May	.	.	.	.	.	56%	27%	80%	65%
Jun-Aug	.	.	.	.	.	38%	69%	13%	29%
Sep-Dec	.	.	.	.	.	6%	4%	6%	6%

Sources: 1981-90 - PacFIN, 1990 - Weekly processor report, 1991-92 - Blend estimates.

Table A9 Distribution of domestic BSAI Pacific cod catch by fishery and month, 1990-92.

Cod catch in thousands of metric tons

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990													
Longline													
Cod	2.58	3.49	1.89	1.66	3.51	4.14	5.39	7.11	5.31	6.12	3.55	2.65	47.40
Non-cod	.01	.01	.00	.00	.03	.02	.05	.04	.	.02	.00	.	.19
Pot													
Cod	.	.	.	.	.00	.	.36	.63	.20	.17	.02	.	1.39
Trawl													
Cod	12.48	18.40	19.87	12.26	12.17	6.18	.25	.02	.06	.19	2.55	2.33	86.77
Non-cod	4.25	2.79	2.14	3.91	4.12	4.60	1.32	2.60	3.71	1.75	.27	.11	31.57
1991													
Longline													
Cod	4.78	4.90	4.96	6.76	7.23	6.48	6.23	8.69	6.44	7.15	9.71	6.07	79.39
Non-cod	.00	.00	.04	.02	.00	.01	.11	.08	.02	.01	.01	.00	.32
Pot													
Cod	.	.00	.02	.03	.	.	.72	2.13	1.28	1.50	.54	.45	6.67
Trawl													
Cod	11.24	13.61	16.04	43.13	5.80	.01	.30	.00	.	.	.	.	90.14
Non-cod	7.32	8.03	2.74	1.37	2.11	2.57	5.82	8.16	2.53	.89	.00	.	41.55
1992													
Longline													
Cod	7.87	9.88	10.68	17.38	10.45	10.23	15.83	12.37	6.21	.	.	.	100.9
Non-cod	.00	.13	.00	.01	.00	.01	.05	.07	.01	.	.	.	.28
Pot													
Cod	.05	.00	.00	.42	3.19	2.72	4.32	2.38	.59	.	.	.	13.68
Non-cod	.	.	.	.	.	.00	.	.00	.	.	.	.	.00
Trawl													
Cod	1.25	4.96	16.70	23.04	1.71	.22	.	.00	.	.	.	.	47.88
Non-cod	6.86	11.59	2.75	2.76	1.03	3.45	4.91	3.38	2.57	1.77	.36	.95	42.39

Table A9 Continued.

Percent distibution of cod catch among months by fishery

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990													
Longline													
Cod	5%	7%	4%	3%	7%	9%	11%	15%	11%	13%	7%	6%	100%
Non-cod	6%	7%	0%	2%	13%	12%	24%	23%	.	12%	1%	.	100%
Pot													
Cod	.	.	.	.	0%	.	26%	46%	15%	12%	2%	.	100%
Trawl													
Cod	14%	21%	23%	14%	14%	7%	0%	0%	0%	0%	3%	3%	100%
Non-cod	13%	9%	7%	12%	13%	15%	4%	8%	12%	6%	1%	0%	100%
1991													
Longline													
Cod	6%	6%	6%	9%	9%	8%	8%	11%	8%	9%	12%	8%	100%
Non-cod	0%	1%	13%	7%	1%	2%	36%	25%	7%	3%	3%	1%	100%
Pot													
Cod	.	0%	0%	1%	.	.	11%	32%	19%	23%	8%	7%	100%
Trawl													
Cod	12%	15%	18%	48%	6%	0%	0%	0%	.	.	.	.	100%
Non-cod	18%	19%	7%	3%	5%	6%	14%	20%	6%	2%	0%	.	100%
1992													
Longline													
Cod	8%	10%	11%	17%	10%	10%	16%	12%	6%	.	.	.	100%
Non-cod	1%	47%	0%	4%	1%	2%	18%	25%	2%	.	.	.	100%
Pot													
Cod	0%	0%	0%	3%	23%	20%	32%	17%	4%	.	.	.	100%
Non-cod	.	.	.	.	.	49%	.	51%	.	.	.	.	100%
Trawl													
Cod	3%	10%	35%	48%	4%	0%	.	0%	.	.	.	.	100%
Non-cod	16%	27%	6%	7%	2%	8%	12%	8%	6%	4%	1%	2%	100%

Table A9 Continued.

Percent distibution of cod catch among fisheries by month

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990													
Longline													
Cod	13%	14%	8%	9%	18%	28%	73%	68%	57%	74%	56%	52%	28%
Non-cod	0%	0%	0%	0%	0%	0%	1%	0%	.	0%	0%	.	0%
Pot													
Cod	.	.	.	.	0%	.	5%	6%	2%	2%	0%	.	1%
Trawl													
Cod	65%	75%	83%	69%	61%	41%	3%	0%	1%	2%	40%	46%	52%
Non-cod	22%	11%	9%	22%	21%	31%	18%	25%	40%	21%	4%	2%	19%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1991													
Longline													
Cod	20%	18%	21%	13%	48%	71%	47%	46%	63%	75%	95%	93%	36%
Non-cod	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%
Pot													
Cod	.	0%	0%	0%	.	.	5%	11%	12%	16%	5%	7%	3%
Trawl													
Cod	48%	51%	67%	84%	38%	0%	2%	0%	.	.	.	.	41%
Non-cod	31%	30%	12%	3%	14%	28%	44%	43%	25%	9%	0%	.	19%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1992													
Longline													
Cod	49%	37%	35%	40%	64%	62%	63%	68%	66%	.	.	.	49%
Non-cod	0%	0%	0%	0%	0%	0%	0%	0%	0%	.	.	.	0%
Pot													
Cod	0%	0%	0%	1%	19%	16%	17%	13%	6%	.	.	.	7%
Non-cod	.	.	.	.	.	0%	.	0%	.	.	.	.	0%
Trawl													
Cod	8%	19%	55%	53%	10%	1%	.	0%	.	.	.	.	23%
Non-cod	43%	44%	9%	6%	6%	21%	20%	19%	27%	100%	100%	100%	21%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Sources: Weekly processor report data - 1990.
Blend estimates 1991-92.

Table A10 Annual distribution of BSAI Pacific cod catch in the domestic (DAP) fishery by gear and target species, 1990-92 (metric tons).

Gear/Target species	1990 Catch	1990 %	1991 Catch	1991 %	1992 Catch	1992 %
Longline						
Pacific cod	47,404	99.6%	79,387	99.6%	100,903	99.7%
Rockfish	7	.0%	2	.0%	.	.
Sablefish	131	.3%	283	.4%	139	.1%
Turbot	36	.1%	0	.0%	.	.
Other	20	.0%	31	.0%	140	.1%
Total	47,598	100%	79,703	100%	101,182	100%
Pot						
Pacific cod	1,386	100%	6,673	100%	13,680	100%
Sablefish	.	.	.	.	0	.0%
Other	.	.	.	.	0	.0%
Total	1,386	100%	6,673	100%	13,680	100%
Trawl						
Pacific cod	86,770	73.3%	90,141	68.5%	47,885	53.0%
Arrowth fl.	44	.0%	25	.0%	.	.
Atka mack.	3,608	3.0%	2,411	1.8%	3,404	3.8%
Flat-other	34	.0%	957	.7%	449	.5%
Pollock-bot	17,138	14.5%	22,013	16.7%	19,615	21.7%
Pollock-mid	5,467	4.6%	4,621	3.5%	3,657	4.1%
Rock sole	2,939	2.5%	6,365	4.8%	5,292	5.9%
Rockfish	1,580	1.3%	1,028	.8%	1,232	1.4%
Sablefish	6	.0%	12	.0%	.	.
Turbot	112	.1%	115	.1%	.	.
Yellowfin	546	.5%	3,994	3.0%	8,533	9.5%
Other	93	.1%	7	.0%	204	.2%
Total	118,336	100%	131,688	100%	90,272	100%
Other						
Pacific cod	139	100%	.	.	117	60.6%
Other	.	.	.	.	76	39.4%
Total	139	100%	.	.	192	100%
Grand total	167,458	100%	218,064	100%	205,326	100%

Sources: Weekly processor report data - 1990.
Blend estimates - 1991-92.

Table A11 Cod bycatch rates in other groundfish fisheries by gear and target species, 1990-92.

Cod catch as a percent of other groundfish catch

Gear/Target species	1990	1991	1992
Longline			
Arrowth fl.	.	.0%	.
Rockfish	21.0%	7.4%	.0%
Sablefish	3.5%	6.3%	3.5%
Turbot	9.4%	.2%	.
Other	11.0%	69.7%	.
Total	4.5%	6.8%	3.5%
Pot			
Sablefish	.	.0%	45.7%
Other	.	.0%	.0%
Total	.	.0%	1.8%
Trawl			
Arrowth fl.	2.8%	1.0%	.
Atka mack.	12.7%	8.6%	6.9%
Flat-other	4.6%	6.7%	6.5%
Pollock-bot	10.5%	6.1%	3.0%
Pollock-mid	.5%	.4%	.5%
Rock sole	10.1%	8.7%	10.6%
Rockfish	5.2%	11.4%	6.8%
Sablefish	.8%	2.2%	.0%
Turbot	.9%	1.4%	.
Yellowfin	3.1%	2.9%	4.5%
Other	35.9%	2.8%	27.7%
Total	2.1%	2.2%	2.4%

Source: Weekly processor report - 1990.
Blend estimates - 1991-92.

Table A12 Cumulative cod catch and cumulative halibut bycatch by gear and date, 1992.

Week ending	Longline Cod	Longline Other	Pot Cod	Pot Other	Trawl Cod	Trawl Other	Total Cod	Trawl Cod Halibut	Longline Halibut
1/05	1,228	0	14	0	0	0	1,242	0	59
1/12	2,246	0	27	0	0	0	2,273	0	109
1/19	3,901	3	47	0	0	0	3,951	0	159
1/26	5,854	3	49	0	146	3,401	9,453	6	218
2/02	7,871	4	49	0	1,249	6,865	16,037	53	278
2/09	9,875	4	50	0	3,234	10,883	24,047	136	324
2/16	12,229	134	50	0	6,033	14,208	32,654	190	370
2/23	14,720	134	50	0	6,210	16,858	37,972	193	414
3/01	17,748	135	50	0	6,210	18,456	42,598	193	446
3/08	19,744	135	50	0	6,735	19,555	46,219	215	499
3/15	22,489	135	50	0	12,059	20,133	54,865	352	553
3/22	25,429	135	52	0	17,713	20,552	63,881	502	600
3/29	28,432	135	52	0	22,914	21,208	72,741	634	687
4/05	31,788	144	63	0	26,194	21,946	80,135	707	877
4/12	34,996	145	88	0	32,997	22,844	91,069	891	997
4/19	38,240	145	125	0	37,700	23,596	99,806	1,078	1,133
4/26	41,816	145	198	0	42,542	23,971	108,673	1,395	1,293
5/03	45,816	146	474	0	45,956	23,971	116,364	1,663	1,452
5/10	48,722	147	906	0	47,489	24,014	121,277	1,787	1,551
5/17	50,831	147	1,846	0	47,654	24,259	124,737	1,793	1,668
5/24	53,440	148	2,838	0	47,657	24,900	128,983	1,793	1,867
5/31	56,263	148	3,667	0	47,668	25,000	132,746	1,793	2,151
6/07	59,020	148	4,309	0	47,668	26,026	137,171	1,793	2,499
6/14	61,157	149	4,938	0	47,668	27,228	141,139	1,793	2,809
6/21	63,674	150	5,682	0	47,877	27,836	145,220	1,798	3,257
6/28	66,498	154	6,389	0	47,883	28,450	149,375	1,798	3,883
7/05	69,251	155	7,373	0	47,883	29,503	154,165	1,798	4,534
7/12	72,479	158	8,285	0	47,883	30,396	159,202	1,798	4,991
7/19	76,215	160	9,078	0	47,883	31,571	164,908	1,798	5,345
7/26	79,431	164	9,999	0	47,883	32,760	170,238	1,798	5,728
8/02	82,329	203	10,705	0	47,883	33,360	174,482	1,798	6,105
8/09	85,934	225	11,412	0	47,883	33,835	179,289	1,798	6,536
8/16	89,236	244	12,165	0	47,885	34,909	184,439	1,798	6,935
8/23	92,209	259	12,632	1	47,885	35,807	188,792	1,798	7,232
8/30	94,696	273	13,089	1	47,885	36,739	192,681	1,798	7,572
9/06	97,218	273	13,220	1	47,885	37,503	196,098	1,798	7,811
9/13	99,440	273	13,493	1	47,885	38,001	199,092	1,798	8,012
9/20	100,903	278	13,680	1	47,885	38,703	201,449	1,798	8,162
9/27	100,903	278	13,680	1	47,885	39,311	202,058	1,798	8,165

Table A12 Continued.

Week ending	Longline Cod	Longline Other	Pot Cod	Pot Other	Trawl Cod	Trawl Other	Total Cod	Trawl Cod Halibut	Longline Halibut
10/04	100,903	278	13,680	1	47,885	39,739	202,486	1,798	8,165
10/11	100,903	278	13,680	1	47,885	40,051	202,798	1,798	8,165
10/18	100,903	278	13,680	1	47,885	40,351	203,098	1,798	8,165
10/25	100,903	278	13,680	1	47,885	40,737	203,483	1,798	8,165
11/01	100,903	278	13,680	1	47,885	41,081	203,827	1,798	8,165
11/08	100,903	278	13,680	1	47,885	41,230	203,976	1,798	8,165
11/15	100,903	278	13,680	1	47,885	41,317	204,064	1,798	8,165
11/22	100,903	278	13,680	1	47,885	41,404	204,151	1,798	8,165
11/29	100,903	278	13,680	1	47,885	41,442	204,189	1,798	8,165
12/06	100,903	278	13,680	1	47,885	41,547	204,293	1,798	8,165
12/13	100,903	278	13,680	1	47,885	41,819	204,566	1,798	8,165
12/20	100,903	278	13,680	1	47,885	42,026	204,773	1,798	8,165
12/27	100,903	278	13,680	1	47,885	42,235	204,982	1,798	8,165
12/31	100,903	278	13,680	1	47,885	42,387	205,134	1,798	8,165

Source: Blend estimates.

Table A13 Distribution of Pacific cod catch among at-sea and onshore processors for each of three domestic BSAI Pacific cod fisheries, 1990-92 (metric tons).

	1990		1991		1992	
Longline						
At-Sea	46,533	98%	78,109	98%	100,312	99%
Onshore	870	2%	1,278	2%	592	1%
Pot						
At-Sea	1,027	74%	5,781	87%	9,670	71%
Onshore	358	26%	892	13%	4,010	29%
Trawl						
At-Sea	59,402	68%	59,274	66%	38,057	79%
Onshore	27,367	32%	30,867	34%	9,828	21%

Sources: Weekly processor report data - 1990.
Blend estimates - 1991-92.

Table A14 Percent distribution of species mix in each of three domestic BSAI Pacific cod fisheries, 1990-92.

	Longline gear			Pot gear			Trawl gear		
Species	1990	1991	1992	1990	1991	1992	1990	1991	1992
Pacific cod	93%	85%	85%	98%	96%	95%	64%	58%	59%
Arrowth fl.	1%	2%	1%	0%	0%	0%	2%	2%	4%
Atka mackerel	0%	0%	0%	.	0%	0%	1%	1%	4%
Flat-other	0%	0%	0%	1%	0%	0%	4%	3%	3%
Pollock	1%	3%	3%	0%	0%	0%	19%	27%	21%
Rock sole	0%	0%	0%	.	0%	0%	5%	4%	4%
Rockfish	0%	0%	1%	.	0%	0%	1%	2%	1%
Sablefish	0%	0%	0%	.	0%	0%	0%	0%	0%
Turbot	0%	1%	0%	0%	0%	0%	0%	0%	0%
Yellowfin	0%	0%	0%	1%	1%	0%	1%	0%	0%
Other	5%	8%	9%	1%	3%	5%	4%	3%	4%

Source: Weekly processor report data - 1990.
Blend estimates - 1991-92.

Table A15 Annual estimated gross wholesale value for each of three domestic BSAI cod fisheries in thousands of dollars, 1990-92.

	1990	1991	1992
Longline cod fishery			
Cod	52,795	56,384	70,761
Other groundfish	1,044	2,127	2,001
Total value	53,840	58,511	72,762
Pot cod fishery			
Cod	1,501	3,921	9,695
Other groundfish	4	9	104
Total value	1,505	3,930	9,799
Trawl cod fishery			
Cod	94,491	93,782	48,553
Other groundfish	9,643	9,477	5,712
Total value	104,134	103,259	54,265

Source: Weekly processor report data 1990-91,
Product data 1992.

Table A16 Estimated retained, discarded, and total catch for each of three domestic BSAI cod fisheries, 1990-92.

Year/Gear/Species	Retained	Discarded	Total	% Retained
1990				
Longline				
Cod	47,358	45	47,404	100%
Other groundfish	1,066	4,124	5,190	21%
Pot				
Cod	1,382	4	1,386	100%
Other groundfish	2	44	45	4%
Trawl				
Cod	83,709	3,061	86,770	96%
Other groundfish	8,703	40,402	49,106	18%
1991				
Longline				
Cod	77,842	1,545	79,387	98%
Other groundfish	2,215	11,318	13,533	16%
Pot				
Cod	6,498	175	6,673	97%
Other groundfish	32	239	271	12%
Trawl				
Cod	87,042	3,099	90,141	97%
Other groundfish	9,785	54,953	64,738	15%
1992				
Longline				
Cod	99,035	1,868	100,903	98%
Other Groundfish	1,724	16,331	18,055	10%
Pot				
Cod	13,577	103	13,680	99%
Other groundfish	91	653	744	12%
Trawl				
Cod	44,548	3,337	47,885	93%
Other groundfish	5,820	27,337	33,157	18%

Source: Weekly processor report data - 1990.
Blend estimates - 1991-92.

Table A17 Annual weight (metric tons) by cod product form for three domestic BSAI Pacific cod fisheries, 1990-92.

Gear/Product	1990 Quantity	1990 %	1991 Quantity	1991 %	1992 Quantity	1992 %
Longline						
Whole fish	47	0%	105	0%	27	0%
H & G	27,746	93%	34,962	96%	42,521	96%
Salted & split	20	0%	127	0%	40	0%
Roe only	213	1%	207	1%	427	1%
Fillets	13	0%	163	0%	802	2%
Minced fish	.	.	10	0%	150	0%
Fish meal	1	0%	13	0%	8	0%
Other	1,691	6%	811	2%	481	1%
Pot						
Whole fish	25	3%	9	0%	16	0%
H & G	715	84%	1,850	78%	4,366	79%
Salted & split	1	0%	141	6%	374	7%
Fillets	49	6%	43	2%	325	6%
Minced fish	.	.	.	.	104	2%
Fish meal	12	1%	2	0%	158	3%
Other	44	5%	319	13%	161	3%
Trawl						
Whole fish	4,129	10%	7,701	20%	686	4%
H & G	16,704	41%	10,963	29%	5,337	32%
Salted & split	6,275	15%	6,438	17%	2,304	14%
Roe only	409	1%	353	1%	185	1%
Fillets	7,860	19%	7,587	20%	5,131	31%
Surimi	.	.	.	.	176	1%
Minced fish	715	2%	1,178	3%	1,166	7%
Fish meal	128	0%	2,394	6%	1,523	9%
Other	4,467	11%	1,473	4%	300	2%

Source: Weekly processor report data - 1990-91, product data - 1992.

Table A18 Blend estimates of BSAI groundfish catch (metric tons) by species and target fishery, 1991-92.

	Pacific cod	Arrow tooth	Atka mack	Flat other	Pollock	Rock sole	Rock fish	Sable fish	Turbot	Yellow fin	Other	Total
1991												
Longline target												
Cod	79,387	2,155	3	327	2,576	22	288	358	575	3	7,225	92,920
Arr	.	5	.	.	.	.	0	3	1	.	0	8
Rckf	2	1	.	3	.	.	13	9	3	.	0	30
Sabl	283	196	0	26	8	0	279	2,528	1,300	.	125	4,745
Turb	0	1	.	1	.	.	1	6	12	.	2	23
Oth	25	1	.	0	0	.	.	.	.	.	35	61
Subtot	79,697	2,358	4	357	2,584	22	581	2,905	1,890	3	7,386	97,787
Pot target												
Cod	6,673	1	2	1	3	0	2	0	0	39	224	6,943
Sabl	.	0	.	.	.	.	.	0	0	.	.	0
Oth	.	.	.	.	.	.	.	.	.	.	0	0
Subtot	6,673	1	2	1	3	0	2	0	0	39	224	6,944
Trawl target												
Cod	90,141	3,466	897	4,509	41,060	6,560	2,648	17	190	592	4,799	154,879
Arr	25	1,463	2	126	171	2	99	30	403	0	113	2,434
Atk	2,411	172	24,975	56	926	122	814	55	46	.	884	30,459
Flat	957	602	.	4,027	3,112	1,235	19	2	9	4,276	891	15,129
PolB	22,013	7,814	562	5,758	336,500	2,585	645	28	209	856	4,172	381,142
PolP	4,621	575	8	1,411	1215194	234	289	1	123	52	1,485	1223995
Rcks	6,365	712	1	6,157	20,040	36,283	88	8	1	7,231	2,830	79,715
Rckf	1,028	1,497	215	361	809	106	5,270	47	127	6	603	10,069
Sabl	12	155	.	19	28	.	29	97	189	.	23	551
Turb	115	1,995	70	152	221	9	106	257	5,060	0	213	8,196
Yelf	3,994	175	1	13,410	8,062	9,665	29	1	0	104,596	3,802	143,735
Oth	2	45	.	5	2	0	0	1	0	.	20	76
Subtot	131,683	18,671	26,732	35,991	1626125	56,800	10,035	543	6,357	117,609	19,835	2050381
Total	218,052	21,030	26,737	36,349	1628711	56,823	10,617	3,448	8,248	117,651	27,445	2155112

Table A18 Continued.

	Pacific cod	Arrow tooth	Atka mack	Flat other	Pollock	Rock sole	Rock fish	Sable fish	Turbot	Yellow fin	Other	Total
1992												
Longline target												
Cod	100,903	1,655	57	275	3,188	28	838	179	576	91	11,166	118,957
Rckf	.	1	.	0	.	.	1	0	2	.	0	4
Sabl	139	268	.	6	1	.	304	1,807	1,445	.	146	4,116
Subtot	101,042	1,924	57	281	3,190	28	1,143	1,987	2,024	91	11,312	123,077
Pot target												
Cod	13,680	3	12	1	7	2	3	13	9	24	669	14,423
Sabl	0	0	.	.	0	.	0	0	.	.	0	1
Oth	.	.	.	.	.	.	.	.	.	.	15	15
Subtot	13,680	4	12	1	7	2	3	13	9	24	684	14,439
Trawl target												
Cod	47,885	2,865	3,073	2,487	16,679	3,502	1,176	10	81	277	3,007	81,042
Atk	3,404	205	44,358	39	683	44	3,494	5	34	0	193	52,460
Flat	449	351	13	1,342	1,327	699	33	1	14	1,527	1,583	7,339
PolB	19,615	3,743	296	7,388	635,298	6,651	507	6	174	818	4,567	679,063
PolP	3,657	325	44	1,223	756,951	443	132	2	134	23	1,356	764,290
Rcks	5,292	526	8	4,845	10,073	26,094	0	.	0	6,636	1,974	55,448
Rckf	1,232	1,556	2,164	243	1,338	61	11,936	25	220	0	552	19,328
Sabl	.	1	.	.	.	.	2	26	2	.	1	31
Yelf	8,533	437	1	17,033	12,815	14,413	0	0	1	137,384	7,915	198,533
Oth	193	7	.	1	4	0	33	.	0	.	650	888
Subtot	90,261	10,017	49,957	34,601	1435168	51,907	17,314	75	661	146,664	21,797	1858422
Total	204,983	11,945	50,026	34,883	1438365	51,937	18,460	2,074	2,693	146,779	33,793	1995938

Source: NMFS Alaska Region blend estimates - 1991-92.

Table A19 Estimated bycatch for BSAI domestic groundfish fisheries by species and fishery, 1990-92.

Bering Sea/Aleutian Islands 1990

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	1,736.4	1,496	2	4	22	
G. turbot	22.3	7	0	0	0	
Rockfish	2.3	0	0	0	0	
Sablefish	332.1	46	0	0	0	
Other	8.4	26	0	0	0	
All targets	2,108.7	1,580	2	4	22	
Pot						
Pacific cod	21.2	20,023	9,762	0	0	
All targets	21.2	20,023	9,762	0	0	
Trawl						
Pacific cod	1,456.4	431,222	18,912	3,264	107	
Arrowtooth	2.5	1,936	13	0	2	
Atka mackerel	138.2	252	259	90	234	
Flatfish	2.2	4,792	484	1	1	
G. turbot	157.5	2,954	1,184	88	81	
Bottom pollock	665.2	176,204	7,339	1,344	1,723	
Pelagic pollock	2,183.9	567,586	11,526	8,701	13,832	
Rock sole	283.8	406,978	58,106	201	11	
Rockfish	125.7	2,909	583	93	206	
Sablefish	4.9	2,120	47	5	0	
Yellowfin	53.2	112,976	900	19	14	
Other	.4	342	0	1	1	
All targets	5,075.9	1,710,657	99,428	13,810	16,215	
All gears/targets	7,205.8	1,732,259	109,192	13,814	16,237	

Bering Sea/Aleutian Islands 1991

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	3,714.0	12,262	111	55	61	.0
Arrowtooth	8.3	0	0	0	0	.0
G. turbot	.5	2	0	0	0	.0
Rockfish	3.0	1	0	0	0	.0
Sablefish	343.7	33	71	0	0	.0
Other	1.2	12	0	0	0	.0
All targets	4,071.8	12,310	182	55	61	.0
Pot						
Pacific cod	59.4	110,506	11,797	0	0	.0
Sablefish	.0	2	0	0	0	.0
All targets	59.4	110,508	11,797	0	0	.0
Trawl						
Pacific cod	2,924.3	645,179	4,811	7,410	66	17.8
Arrowtooth	73.3	1,366	7	2	89	.2
Atka mackerel	68.1	324	148	152	20	.0
Flatfish	75.2	239,510	2,346	47	76	27.8
G. turbot	403.8	16,709	1,497	39	8	.0
Bottom pollock	1,180.1	1,013,748	2,596	5,596	11,253	275.8
Pelagic pollock	271.9	49,818	269	27,782	22,123	535.8
Rock sole	1,361.3	854,602	97,960	869	1,040	25.9
Rockfish	167.0	5,873	165	816	7	.2
Sablefish	41.3	718	2	1	1	.0
Yellowfin	794.1	799,852	23,595	538	1,038	582.5
Other	1.0	2,612	1	2	1	.0
All targets	7,364.2	3,631,326	133,511	43,256	35,723	1,466.4
All gears/targets	11,495.5	3,754,144	145,491	43,311	35,785	1,466.4

Table A19 Continued.

Bering Sea/Aleutian Islands 1992

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	7,926.3	24,084	2,921	49	117	.0
Rockfish	.5	1	0	0	0	.0
Sablefish	235.5	17	46	0	0	.0
All targets	8,164.6	24,123	2,967	50	117	.0
Pot						
Pacific cod	113.1	243,289	10,540	0	0	.0
All targets	113.2	243,289	10,540	0	0	.0
Trawl						
Pacific cod	1,798.3	195,479	206	4,942	33	5.9
Atka mackerel	109.4	563	130	35	8	.0
Flatfish	42.5	91,426	2,427	65	0	1.0
Bottom pollock	1,961.6	1,527,206	44,290	15,994	3,747	24.9
Pelagic pollock	238.8	11,605	879	19,906	35,860	612.7
Rock sole	796.0	832,191	60,877	37	0	9.5
Rockfish	234.7	4,181	873	1,169	5	.0
Sablefish	.6	0	0	0	0	.0
Yellowfin	844.7	1,582,089	63,675	198	1,017	417.6
Other	2.7	3	0	5	0	.0
All targets	6,033.9	4,248,357	173,389	42,351	40,671	1,071.7
All gears/targets	14,311.7	4,515,768	186,896	42,400	40,788	1,071.7

Source: Weekly processor report data 1990.
Blend estimates 1991 - 1992.
Observer PSC data 1990 - 1992.

Note: Bycatch has not been adjusted for mortality.
Herring bycatch for 1990 were not available.

Table A20 Estimated bycatch mortality for BSAI domestic groundfish fisheries by species and fishery, 1990-92.

Bering Sea/Aleutian Islands 1990

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	347.3	553	1	4	22	
G. turbot	4.5	3	0	0	0	
Rockfish	.5	0	0	0	0	
Sablefish	66.4	17	0	0	0	
Other	1.7	10	0	0	0	
All targets	421.7	585	1	4	22	
Pot						
Pacific cod	1.1	7,409	2,929	0	0	
All targets	1.1	7,409	2,929	0	0	
Trawl						
Pacific cod	873.8	344,977	15,130	3,264	107	
Arrowtooth	1.0	1,549	10	0	2	
Atka mackerel	96.7	202	207	90	234	
Flatfish	1.5	3,834	387	1	1	
G. turbot	63.0	2,363	947	88	81	
Bottom pollock	399.1	140,963	5,871	1,344	1,723	
Pelagic pollock	1,747.1	454,069	9,221	8,701	13,832	
Rock sole	198.7	325,582	46,485	201	11	
Rockfish	75.4	2,327	467	93	206	
Sablefish	2.0	1,696	37	5	0	
Yellowfin	37.2	90,381	720	19	14	
Other	.2	274	0	1	1	
All targets	3,497.8	1,368,525	79,543	13,810	16,215	
All gears/targets	3,920.6	1,376,518	82,472	13,814	16,237	

Bering Sea/Aleutian Islands 1991

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	742.8	4,537	50	55	61	.0
Arrowtooth	1.7	0	0	0	0	.0
G. turbot	.1	1	0	0	0	.0
Rockfish	.6	0	0	0	0	.0
Sablefish	68.7	12	32	0	0	.0
Other	.2	5	0	0	0	.0
All targets	814.4	4,555	82	55	61	.0
Pot						
Pacific cod	3.0	40,887	3,539	0	0	.0
Sablefish	.0	1	0	0	0	.0
Other	.0	0	0	0	0	.0
All targets	3.0	40,888	3,539	0	0	.0
Trawl						
Pacific cod	1,754.6	516,144	3,849	7,410	66	17.8
Arrowtooth	29.3	1,093	6	2	89	.2
Atka mackerel	47.7	259	118	152	20	.0
Flatfish	52.7	191,608	1,877	47	76	27.8
G. turbot	161.5	13,367	1,198	39	8	.0
Bottom pollock	708.1	810,999	2,077	5,596	11,253	275.8
Pelagic pollock	217.5	39,855	215	27,782	22,123	535.8
Rock sole	952.9	683,682	78,368	869	1,040	25.9
Rockfish	100.2	4,698	132	816	7	.2
Sablefish	16.5	575	2	1	1	.0
Yellowfin	555.9	639,882	18,876	538	1,038	582.5
Other	.4	2,090	1	2	1	.0
All targets	4,600.0	2,905,061	106,809	43,256	35,723	1,466.4
All gears/targets	5,417.3	2,950,504	110,430	43,311	35,785	1,466.4

Table A20 Continued.

Bering Sea/Aleutian Islands 1992

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	1,585.3	8,911	1,314	49	117	.0
Rockfish	.1	0	0	0	0	.0
Sablefish	47.1	6	21	0	0	.0
All targets	1,632.9	8,925	1,335	50	117	.0
Pot						
Pacific cod	5.7	90,017	3,162	0	0	.0
All targets	5.7	90,017	3,162	0	0	.0
Trawl						
Pacific cod	1,079.0	156,383	165	4,942	33	5.9
Atka mackerel	76.6	451	104	35	8	.0
Flatfish	29.7	73,141	1,941	65	0	1.0
Bottom pollock	1,177.0	1,221,765	35,432	15,994	3,747	24.9
Pelagic pollock	191.1	9,284	703	19,906	35,860	612.7
Rock sole	557.2	665,753	48,702	37	0	9.5
Rockfish	140.8	3,344	699	1,169	5	.0
Sablefish	.3	0	0	0	0	.0
Yellowfin	591.3	1,265,672	50,940	198	1,017	417.6
Other	1.1	2	0	5	0	.0
All targets	3,848.5	3,398,685	138,711	42,351	40,671	1,071.7
All gears/targets	5,487.1	3,497,627	143,208	42,400	40,788	1,071.7

Source: Weekly processor report data 1990.
Blend estimates 1991 - 1992.
Observer PSC data 1990 - 1992.

Note: Longline and pot bycatch has been adjusted for mortality by gear; Trawl bycatch has been adjusted for mortality by gear and target. Herring bycatch for 1990 were not available.

Table A21 Estimated bycatch rates for BSAI domestic groundfish fisheries by species and fishery, 1990-92.

Bering Sea/Aleutian Islands 1990

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	3.39	.03	.00	.00	.00	
G. turbot	5.28	.02	.00	.00	.00	
Rockfish	5.64	.00	.00	.00	.00	
Sablefish	8.52	.01	.00	.00	.00	
Other	4.16	.13	.00	.00	.00	
All targets	3.63	.03	.00	.00	.00	
Pot						
Pacific cod	1.49	14.12	6.88	.00	.00	
All targets	1.49	14.12	6.88	.00	.00	
Trawl						
Pacific cod	1.08	3.19	.14	.02	.00	
Arrowtooth	.16	1.18	.01	.00	.00	
Atka mackerel	.43	.01	.01	.00	.01	
Flatfish	.29	6.20	.63	.00	.00	
G. turbot	1.21	.23	.09	.01	.01	
Bottom pollock	.37	.98	.04	.01	.01	
Pelagic pollock	.18	.47	.01	.01	.01	
Rock sole	.88	12.68	1.81	.01	.00	
Rockfish	.40	.09	.02	.00	.01	
Sablefish	.71	3.07	.07	.01	.00	
Yellowfin	.29	6.23	.05	.00	.00	
Other	.98	7.52	.01	.02	.01	
All targets	.31	1.04	.06	.01	.01	
All gears/targets	.42	1.02	.06	.01	.01	

Bering Sea/Aleutian Islands 1991

Longline						
Pacific cod	4.00	.13	.00	.00	.00	.00
Arrowtooth	98.51	.00	.00	.00	.00	.00
G. turbot	2.39	.07	.00	.00	.00	.00
Rockfish	10.06	.02	.00	.00	.00	.00
Sablefish	7.24	.01	.02	.00	.00	.00
Other	1.95	.20	.00	.00	.00	.00
All targets	4.16	.13	.00	.00	.00	.00
Pot						
Pacific cod	.86	15.92	1.70	.00	.00	.00
Sablefish	.76	6.47	.91	.00	.00	.00
All targets	.86	15.91	1.70	.00	.00	.00
Trawl						
Pacific cod	1.89	4.17	.03	.05	.00	.01
Arrowtooth	3.01	.56	.00	.00	.04	.01
Atka mackerel	.22	.01	.00	.01	.00	.00
Flatfish	.50	15.83	.16	.00	.01	.18
G. turbot	4.93	2.04	.18	.00	.00	.00
Bottom pollock	.31	2.66	.01	.01	.03	.07
Pelagic pollock	.02	.04	.00	.02	.02	.04
Rock sole	1.71	10.72	1.23	.01	.01	.03
Rockfish	1.66	.58	.02	.08	.00	.00
Sablefish	7.50	1.30	.00	.00	.00	.01
Yellowfin	.55	5.56	.16	.00	.01	.41
Other	1.31	34.40	.02	.03	.02	.00
All targets	.36	1.77	.07	.02	.02	.07
All gears/targets	.53	1.74	.07	.02	.02	.07

Table A21 Continued.

Bering Sea/Aleutian Islands 1992

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	6.66	.20	.02	.00	.00	.00
Rockfish	12.43	.14	.00	.00	.00	.00
Sablefish	5.72	.00	.01	.00	.00	.00
All targets	6.62	.20	.02	.00	.00	.00
Pot						
Pacific cod	.78	16.87	.73	.00	.00	.00
All targets	.78	16.85	.73	.00	.00	.00
Trawl						
Pacific cod	2.22	2.41	.00	.06	.00	.01
Atka mackerel	.21	.01	.00	.00	.00	.00
Flatfish	.58	12.46	.33	.01	.00	.01
Bottom pollock	.29	2.25	.07	.02	.01	.00
Pelagic pollock	.03	.02	.00	.03	.05	.08
Rock sole	1.44	15.01	1.10	.00	.00	.02
Rockfish	1.21	.22	.05	.06	.00	.00
Sablefish	2.08	.00	.00	.00	.00	.00
Yellowfin	.43	7.97	.32	.00	.01	.21
Other	.31	.00	.00	.01	.00	.00
All targets	.32	2.29	.09	.02	.02	.06
All gears/targets	.72	2.26	.09	.02	.02	.05

Source: Weekly processor report data 1990.
Blend estimates 1991-92.
Observer PSC data 1990-92.

Note: Bycatch has not been adjusted for mortality.
Herring bycatch for 1990 wre not available.

Table A22 Estimated bycatch mortality rates for BSAI domestic groundfish fisheries by species and fishery, 1990-92.

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Bering Sea/Aleutian Islands 1990						
Longline						
Pacific cod	.68	.01	.00	.00	.00	
G. turbot	1.06	.01	.00	.00	.00	
Rockfish	1.13	.00	.00	.00	.00	
Sablefish	1.70	.00	.00	.00	.00	
Other	.83	.05	.00	.00	.00	
All targets	.73	.01	.00	.00	.00	
Pot						
Pacific cod	.07	5.22	2.07	.00	.00	
All targets	.07	5.22	2.07	.00	.00	
Trawl						
Pacific cod	.65	2.55	.11	.02	.00	
Arrowtooth	.06	.94	.01	.00	.00	
Atka mackerel	.30	.01	.01	.00	.01	
Flatfish	.20	4.96	.50	.00	.00	
G. turbot	.48	.18	.07	.01	.01	
Bottom pollock	.22	.78	.03	.01	.01	
Pelagic pollock	.15	.38	.01	.01	.01	
Rock sole	.62	10.14	1.45	.01	.00	
Rockfish	.24	.07	.01	.00	.01	
Sablefish	.28	2.46	.05	.01	.00	
Yellowfin	.21	4.99	.04	.00	.00	
Other	.39	6.02	.01	.02	.01	
All targets	.21	.83	.05	.01	.01	
All gears/targets	.23	.81	.05	.01	.01	
Bering Sea/Aleutian Islands 1991						
Longline						
Pacific cod	.80	.05	.00	.00	.00	.00
Arrowtooth	19.70	.00	.00	.00	.00	.00
G. turbot	.48	.03	.00	.00	.00	.00
Rockfish	2.01	.01	.00	.00	.00	.00
Sablefish	1.45	.00	.01	.00	.00	.00
Other	.39	.07	.00	.00	.00	.00
All targets	.83	.05	.00	.00	.00	.00
Pot						
Pacific cod	.04	5.89	.51	.00	.00	.00
Sablefish	.04	2.39	.27	.00	.00	.00
All targets	.04	5.89	.51	.00	.00	.00
Trawl						
Pacific cod	1.13	3.33	.02	.05	.00	.01
Arrowtooth	1.20	.45	.00	.00	.04	.01
Atka mackerel	.16	.01	.00	.01	.00	.00
Flatfish	.35	12.67	.12	.00	.01	.18
G. turbot	1.97	1.63	.15	.00	.00	.00
Bottom pollock	.19	2.13	.01	.01	.03	.07
Pelagic pollock	.02	.03	.00	.02	.02	.04
Rock sole	1.20	8.58	.98	.01	.01	.03
Rockfish	.99	.47	.01	.08	.00	.00
Sablefish	3.00	1.04	.00	.00	.00	.01
Yellowfin	.39	4.45	.13	.00	.01	.41
Other	.52	27.52	.01	.03	.02	.00
All targets	.22	1.42	.05	.02	.02	.07
All gears/targets	.25	1.37	.05	.02	.02	.07

Table A22 Continued.

Bering Sea/Aleutian Islands 1992

Fishery	Halibut	Bairdi	Red king	Chinook	O salmon	Herring
Longline						
Pacific cod	1.33	.07	.01	.00	.00	.00
Rockfish	2.49	.05	.00	.00	.00	.00
Sablefish	1.14	.00	.01	.00	.00	.00
All targets	1.32	.07	.01	.00	.00	.00
Pot						
Pacific cod	.04	6.24	.22	.00	.00	.00
All targets	.04	6.23	.22	.00	.00	.00
Trawl						
Pacific cod	1.33	1.93	.00	.06	.00	.01
Atka mackerel	.15	.01	.00	.00	.00	.00
Flatfish	.41	9.97	.26	.01	.00	.01
Bottom pollock	.17	1.80	.05	.02	.01	.00
Pelagic pollock	.02	.01	.00	.03	.05	.08
Rock sole	1.00	12.01	.88	.00	.00	.02
Rockfish	.73	.17	.04	.06	.00	.00
Sablefish	.83	.00	.00	.00	.00	.00
Yellowfin	.30	6.38	.26	.00	.01	.21
Other	.12	.00	.00	.01	.00	.00
All targets	.21	1.83	.07	.02	.02	.06
All gears/targets	.27	1.75	.07	.02	.02	.05

Source: Weekly processor report data 1990.
Blend estimates 1991-92.
Observer PSC data 1990-92.

Note: Longline and pot bycatch has been adjusted for mortality by gear;
Trawl bycatch has been adjusted for mortality by gear and target.
Herring bycatch for 1990 were not available.

Table A23 Estimated halibut bycatch mortality rates for BSAI Pacific cod target, 1990-92.

Halibut given as a percent of groundfish catch

	Jan-May	Jun-Aug	Sep-Dec	Annual
Longline				
1990	.2609%	1.0318%	.6478%	.6781%
1991	.3636%	1.0823%	.9904%	.7994%
1992	.6237%	2.3207%	1.4334%	1.3326%
Pot				
1990	.0000%	.0501%	.1364%	.0746%
1991	.0504%	.0723%	.0207%	.0428%
1992	.0496%	.0346%	.0504%	.0392%
Trawl				
1990	.6780%	.1443%	.9781%	.6464%
1991	1.1360%	.4541%	.	1.1329%
1992	1.3318%	1.2994%	.	1.3317%

Note: The discard mortality rates used to convert bycatch into bycatch mortality are 0.20 for longline, 0.05 for pot, and 0.60 for trawl gear fisheries.

Table A24 Estimated herring bycatch mortality rates for BSAI Pacific cod target, 1991-92.

Herring given as a percent of groundfish catch

	Jan-May	Jun-Aug	Sep-Dec	Annual
Longline				
1991	.00000%	.00000%	.00000%	.00000%
1992	.00000%	.00000%	.00000%	.00000%
Pot				
1991	.00000%	.00000%	.00000%	.00000%
1992	.00000%	.00000%	.00000%	.00000%
Trawl				
1991	.01149%	.00509%	.	.01146%
1992	.00720%	.02783%	.	.00726%

Note: The discard mortality rates used to convert bycatch into bycatch mortality are 1.00 for all gear types.

Source: 1991-92 - Blend estimates.

Table A25 Estimated Tanner and red king crab bycatch mortality rates for BSAI Pacific cod target, 1990-92.

Tanner (C. bairdi) crabs per metric ton of groundfish

	Jan-May	Jun-Aug	Sep-Dec	Annual
Longline				
1990	.0019	.0108	.0235	.0131
1991	.0641	.0640	.0518	.0594
1992	.0640	.1025	.2484	.0911
Pot				
1990	.0000	5.3893	1.3297	4.2357
1991	2.5680	.9726	7.6412	4.7745
1992	2.5873	6.1571	2.4546	5.0603
Trawl				
1990	2.5027	.1096	7.8715	2.5517
1991	3.3445	.7388	.	3.3326
1992	1.9298	1.9533	.	1.9299

Note: The discard mortality rates used to convert bycatch into bycatch mortality are 0.45 for longline, 0.30 for pot, and 0.80 for trawl gear fisheries.

Red king crabs per metric ton of groundfish

	Jan-May	Jun-Aug	Sep-Dec	Annual
Longline				
1990	.0000	.0000	.0000	.0000
1991	.0000	.0004	.0008	.0004
1992	.0009	.0219	.0026	.0091
Pot				
1990	.0000	.5872	7.4922	2.5470
1991	.4477	.0576	1.0572	.6286
1992	.0103	.3846	.0143	.2704
Trawl				
1990	.1281	.0101	.0007	.1119
1991	.0247	.0569	.	.0249
1992	.0020	.0000	.	.0020

Note: The discard mortality rates used to convert bycatch into bycatch mortality are 0.37 for longline, 0.37 for pot, and 0.80 for trawl gear fisheries.

Sources: 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A26 Estimated chinook and other salmon bycatch mortality rates for BSAI Pacific cod target, 1990-92.

Number of chinook per metric ton of groundfish

	Jan-May	Jun-Aug	Sep-Dec	Annual
Longline				
1990	.00032	.00000	.00000	.00009
1991	.00074	.00102	.00015	.00059
1992	.00076	.00000	.00000	.00042
Pot				
1990	.00000	.00000	.00000	.00000
1991	.00000	.00000	.00000	.00000
1992	.00000	.00000	.00000	.00000
Trawl				
1990	.02673	.00077	.01923	.02414
1991	.04806	.00026	.	.04784
1992	.06100	.06607	.	.06101

Note: The discard mortality rates used to convert bycatch into bycatch mortality are 1.00 for all gear types.

Number of other salmon per metric ton of groundfish

	Jan-May	Jun-Aug	Sep-Dec	Annual
Longline				
1990	.00015	.00109	.00000	.00043
1991	.00000	.00215	.00018	.00066
1992	.00011	.00240	.00000	.00098
Pot				
1990	.00000	.00000	.00000	.00000
1991	.00000	.00000	.00000	.00000
1992	.00000	.00000	.00000	.00000
Trawl				
1990	.00011	.00410	.00720	.00079
1991	.00043	.00000	.	.00043
1992	.00041	.00000	.	.00041

Note: The discard mortality rates used to convert bycatch into bycatch mortality are 1.00 for all gear types.

Sources: 1990 - Weekly processor report,
1991-92 - Blend estimates.

Table A27 Annual catch (metric tons) and first wholesale value ($) for three domestic BSAI Pacific cod fisheries compared to other domestic BSAI groundfish fisheries, 1990-92.

Year/Gear/Target	Catch	%	Value	%
1990				
Longline				
Cod	51,211	88%	53,839,634	82%
Other	6,838	12%	11,524,118	18%
Pot				
Cod	1,418	100%	1,504,853	100%
Trawl				
Cod	135,193	8%	104,133,974	13%
Other	1,511,664	92%	670,774,241	87%
All gears				
Cod	187,822	11%	159,478,462	19%
Other	1,518,502	89%	682,298,359	81%
1991				
Longline				
Cod	92,920	95%	58,511,151	85%
Other	4,887	5%	10,486,385	15%
Pot				
Cod	6,943	100%	3,930,380	100%
Other	1	0%	4,113	0%
Trawl				
Cod	154,879	8%	103,258,711	9%
Other	1,895,836	92%	1100317933	91%
All gears				
Cod	254,742	12%	165,700,241	13%
Other	1,900,724	88%	1110808430	87%
1992				
Longline				
Cod	118,957	97%	72,761,916	91%
Other	4,283	3%	7,465,624	9%
Pot				
Cod	14,423	100%	9,798,800	100%
Other	16	0%	10,870	0%
Trawl				
Cod	81,031	4%	54,265,039	5%
Other	1,777,762	96%	1043371253	95%
All gears				
Cod	214,411	11%	136,825,755	11%
Other	1,782,062	89%	1053734255	89%

Source: Weekly processor report data 1990-91; blend data 1991-92; product data 1992.

Table A28 Dependency in terms of weeks fished of catcher-processors on the BSAI cod fishery by year and gear, 1990-92.

Longline catcher-processor 1990

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1	4%	2	45	4%	2	45	4%
2	7%	16	39	41%	18	84	21%
3	11%	13	27	48%	31	111	28%
4	15%	16	32	50%	47	143	33%
5	19%	25	46	54%	72	189	38%
6	22%	16	29	55%	88	218	40%
7	26%	25	45	56%	113	263	43%
8	30%	20	36	56%	133	299	44%
9	33%	26	45	58%	159	344	46%
10	37%	12	19	63%	171	363	47%
11	41%	22	31	71%	193	394	49%
12	44%	30	42	71%	223	436	51%
13	48%	21	28	75%	244	464	53%
14	52%	27	35	77%	271	499	54%
15	56%	4	5	80%	275	504	55%
16	59%	37	45	82%	312	549	57%
17	63%	24	29	83%	336	578	58%
18	67%	36	43	84%	372	621	60%
19	70%	19	22	86%	391	643	61%
20	74%	17	18	94%	408	661	62%
21	78%	48	50	96%	456	711	64%
22	81%	32	33	97%	488	744	66%
23	85%	45	46	98%	533	790	67%
24	89%	14	14	100%	547	804	68%
25	93%	4	4	100%	551	808	68%
26	96%	46	46	100%	597	854	70%
27	100%	6	6	100%	603	860	70%

Table A28 Continued.

Longline catcher-processor 1991

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1	3%	1	38	3%	1	38	3%
2	5%	1	37	3%	2	75	3%
3	8%	2	42	5%	4	117	3%
4	11%	2	38	5%	6	155	4%
5	14%	5	28	18%	11	183	6%
6	16%	2	9	22%	13	192	7%
7	19%	12	22	55%	25	214	12%
8	22%	25	44	57%	50	258	19%
9	24%	25	43	58%	75	301	25%
10	27%	31	43	72%	106	344	31%
11	30%	24	32	75%	130	376	35%
12	32%	23	30	77%	153	406	38%
13	35%	24	30	80%	177	436	41%
14	38%	34	40	85%	211	476	44%
15	41%	38	41	93%	249	517	48%
16	43%	28	30	93%	277	547	51%
17	46%	40	41	98%	317	588	54%
18	49%	46	47	98%	363	635	57%
19	51%	48	49	98%	411	684	60%
20	54%	14	14	100%	425	698	61%
21	57%	7	7	100%	432	705	61%
22	59%	34	34	100%	466	739	63%
23	62%	6	6	100%	472	745	63%
24	65%	42	42	100%	514	787	65%
25	68%	29	29	100%	543	816	67%
26	70%	48	48	100%	591	864	68%
27	73%	52	52	100%	643	916	70%
28	76%	25	25	100%	668	941	71%
29	78%	43	43	100%	711	984	72%
30	81%	15	15	100%	726	999	73%
31	84%	31	31	100%	757	1,030	73%
32	86%	21	21	100%	778	1,051	74%
33	89%	28	28	100%	806	1,079	75%
34	92%	13	13	100%	819	1,092	75%
35	95%	13	13	100%	832	1,105	75%
36	97%	1	1	100%	833	1,106	75%
37	100%	3	3	100%	836	1,109	75%

Table A28 Continued.

Longline catcher-processor 1992

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1	2%	1	33	3%	1	33	3%
2	4%	2	37	5%	3	70	4%
3	6%	2	37	5%	5	107	5%
4	7%	2	32	6%	7	139	5%
5	9%	2	23	9%	9	162	6%
6	11%	2	22	9%	11	184	6%
7	13%	8	34	24%	19	218	9%
8	15%	2	8	25%	21	226	9%
9	17%	11	30	37%	32	256	13%
10	19%	13	31	42%	45	287	16%
11	20%	16	38	42%	61	325	19%
12	22%	13	28	46%	74	353	21%
13	24%	18	36	50%	92	389	24%
14	26%	4	8	50%	96	397	24%
15	28%	18	35	51%	114	432	26%
16	30%	19	36	53%	133	468	28%
17	31%	19	34	56%	152	502	30%
18	33%	22	38	58%	174	540	32%
19	35%	24	37	65%	198	577	34%
20	37%	25	37	68%	223	614	36%
21	39%	19	28	68%	242	642	38%
22	41%	11	16	69%	253	658	38%
23	43%	10	14	71%	263	672	39%
24	44%	14	19	74%	277	691	40%
25	46%	22	28	79%	299	719	42%
26	48%	29	36	81%	328	755	43%
27	50%	17	21	81%	345	776	44%
28	52%	29	34	85%	374	810	46%
29	54%	31	36	86%	405	846	48%
30	56%	25	29	86%	430	875	49%
31	57%	7	8	88%	437	883	49%
32	59%	15	17	88%	452	900	50%
33	61%	30	34	88%	482	934	52%
34	63%	8	9	89%	490	943	52%
35	65%	34	37	92%	524	980	53%
36	67%	29	31	94%	553	1,011	55%
37	69%	32	34	94%	585	1,045	56%
38	70%	22	23	96%	607	1,068	57%
39	72%	26	27	96%	633	1,095	58%
40	74%	27	28	96%	660	1,123	59%
41	76%	29	30	97%	689	1,153	60%
42	78%	29	30	97%	718	1,183	61%
43	80%	33	34	97%	751	1,217	62%
44	81%	37	38	97%	788	1,255	63%
45	83%	14	14	100%	802	1,269	63%
46	85%	32	32	100%	834	1,301	64%
47	87%	36	36	100%	870	1,337	65%
48	89%	21	21	100%	891	1,358	66%
49	91%	26	26	100%	917	1,384	66%
50	93%	35	35	100%	952	1,419	67%
51	94%	35	35	100%	987	1,454	68%
52	96%	11	11	100%	998	1,465	68%
53	98%	37	37	100%	1,035	1,502	69%
54	100%	38	38	100%	1,073	1,540	70%

Table A28 Continued.

Trawl catcher-processor 1990

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1	3%	1	40	3%	1	40	3%
2	5%	1	39	3%	2	79	3%
3	8%	1	26	4%	3	105	3%
4	10%	2	40	5%	5	145	3%
5	13%	2	39	5%	7	184	4%
6	15%	1	16	6%	8	200	4%
7	18%	4	51	8%	12	251	5%
8	20%	3	36	8%	15	287	5%
9	23%	3	34	9%	18	321	6%
10	25%	4	43	9%	22	364	6%
11	28%	5	47	11%	27	411	7%
12	30%	4	37	11%	31	448	7%
13	33%	5	39	13%	36	487	7%
14	35%	6	46	13%	42	533	8%
15	38%	4	28	14%	46	561	8%
16	40%	8	48	17%	54	609	9%
17	43%	6	34	18%	60	643	9%
18	45%	8	40	20%	68	683	10%
19	48%	9	45	20%	77	728	11%
20	50%	8	39	21%	85	767	11%
21	53%	9	33	27%	94	800	12%
22	55%	9	32	28%	103	832	12%
23	58%	13	46	28%	116	878	13%
24	60%	3	10	30%	119	888	13%
25	63%	13	36	36%	132	924	14%
26	65%	16	42	38%	148	966	15%
27	68%	13	33	39%	161	999	16%
28	70%	12	29	41%	173	1,028	17%
29	73%	15	33	45%	188	1,061	18%
30	75%	19	41	46%	207	1,102	19%
31	78%	15	32	47%	222	1,134	20%
32	80%	22	46	48%	244	1,180	21%
33	83%	20	41	49%	264	1,221	22%
34	85%	18	36	50%	282	1,257	22%
35	88%	19	37	51%	301	1,294	23%
36	90%	17	33	52%	318	1,327	24%
37	93%	21	40	53%	339	1,367	25%
38	95%	16	30	53%	355	1,397	25%
39	98%	21	24	88%	376	1,421	26%
40	100%	6	6	100%	382	1,427	27%

Table A28 Continued.

Trawl catcher-processor 1991

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1	2%	1	40	3%	1	40	3%
2	4%	1	35	3%	2	75	3%
3	6%	1	34	3%	3	109	3%
4	8%	1	30	3%	4	139	3%
5	10%	1	27	4%	5	166	3%
6	12%	1	26	4%	6	192	3%
7	14%	2	40	5%	8	232	3%
8	16%	2	37	5%	10	269	4%
9	18%	3	43	7%	13	312	4%
10	20%	3	42	7%	16	354	5%
11	22%	3	42	7%	19	396	5%
12	24%	3	41	7%	22	437	5%
13	25%	3	41	7%	25	478	5%
14	27%	3	38	8%	28	516	5%
15	29%	3	36	8%	31	552	6%
16	31%	4	42	10%	35	594	6%
17	33%	3	30	10%	38	624	6%
18	35%	3	30	10%	41	654	6%
19	37%	4	37	11%	45	691	7%
20	39%	5	43	12%	50	734	7%
21	41%	4	32	13%	54	766	7%
22	43%	5	39	13%	59	805	7%
23	45%	4	31	13%	63	836	8%
24	47%	4	30	13%	67	866	8%
25	49%	4	30	13%	71	896	8%
26	51%	5	36	14%	76	932	8%
27	53%	5	36	14%	81	968	8%
28	55%	6	41	15%	87	1,009	9%
29	57%	5	34	15%	92	1,043	9%
30	59%	5	33	15%	97	1,076	9%
31	61%	6	35	17%	103	1,111	9%
32	63%	5	29	17%	108	1,140	9%
33	65%	7	40	18%	115	1,180	10%
34	67%	3	17	18%	118	1,197	10%
35	69%	6	34	18%	124	1,231	10%
36	71%	7	36	19%	131	1,267	10%
37	73%	7	35	20%	138	1,302	11%
38	75%	8	40	20%	146	1,342	11%
39	76%	7	35	20%	153	1,377	11%
40	78%	8	39	21%	161	1,416	11%
41	80%	8	36	22%	169	1,452	12%
42	82%	10	43	23%	179	1,495	12%
43	84%	10	42	24%	189	1,537	12%
44	86%	9	36	25%	198	1,573	13%
45	88%	12	35	34%	210	1,608	13%
46	90%	13	37	35%	223	1,645	14%
47	92%	13	35	37%	236	1,680	14%
48	94%	13	27	48%	249	1,707	15%
49	96%	6	9	67%	255	1,716	15%
50	98%	15	16	94%	270	1,732	16%
51	100%	18	18	100%	288	1,750	16%

Table A28 Continued.

Trawl catcher-processor 1992

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1	2%	1	42	2%	1	42	2%
2	4%	1	41	2%	2	83	2%
3	7%	1	40	3%	3	123	2%
4	9%	1	38	3%	4	161	2%
5	11%	1	37	3%	5	198	3%
6	13%	1	36	3%	6	234	3%
7	16%	1	35	3%	7	269	3%
8	18%	1	33	3%	8	302	3%
9	20%	1	31	3%	9	333	3%
10	22%	1	30	3%	10	363	3%
11	24%	2	41	5%	12	404	3%
12	27%	1	19	5%	13	423	3%
13	29%	2	34	6%	15	457	3%
14	31%	2	34	6%	17	491	3%
15	33%	2	32	6%	19	523	4%
16	36%	3	41	7%	22	564	4%
17	38%	2	26	8%	24	590	4%
18	40%	3	34	9%	27	624	4%
19	42%	2	22	9%	29	646	4%
20	44%	3	31	10%	32	677	5%
21	47%	4	39	10%	36	716	5%
22	49%	4	35	11%	40	751	5%
23	51%	3	26	12%	43	777	6%
24	53%	4	34	12%	47	811	6%
25	56%	4	33	12%	51	844	6%
26	58%	4	32	13%	55	876	6%
27	60%	4	29	14%	59	905	7%
28	62%	7	47	15%	66	952	7%
29	64%	6	36	17%	72	988	7%
30	67%	4	23	17%	76	1,011	8%
31	69%	7	38	18%	83	1,049	8%
32	71%	9	48	19%	92	1,097	8%
33	73%	9	46	20%	101	1,143	9%
34	76%	4	20	20%	105	1,163	9%
35	78%	4	20	20%	109	1,183	9%
36	80%	10	47	21%	119	1,230	10%
37	82%	7	32	22%	126	1,262	10%
38	84%	7	30	23%	133	1,292	10%
39	87%	9	34	26%	142	1,326	11%
40	89%	9	32	28%	151	1,358	11%
41	91%	10	35	29%	161	1,393	12%
42	93%	8	26	31%	169	1,419	12%
43	96%	8	26	31%	177	1,445	12%
44	98%	9	28	32%	186	1,473	13%
45	100%	9	24	38%	195	1,497	13%

Source: 1990-91 NMFS Alaska Region weekly processor data, 1992 NMFS Alaska Region product data.

Table A29 Dependency of catcher-processors on the BSAI cod fisheries in terms of product value by gear, 1990-92.

Longline catcher-processor 1990

Cum # of ves	Cum % of ves	% cod value	Cum % cod value
1	4%	4%	4%
2	7%	40%	17%
3	11%	44%	21%
4	15%	45%	26%
5	19%	51%	37%
6	22%	52%	39%
7	26%	54%	43%
8	30%	55%	43%
9	33%	57%	44%
10	37%	59%	46%
11	41%	66%	48%
12	44%	79%	53%
13	48%	79%	56%
14	52%	80%	58%
15	56%	82%	59%
16	59%	86%	61%
17	63%	89%	62%
18	67%	90%	66%
19	70%	92%	68%
20	74%	95%	68%
21	78%	97%	72%
22	81%	98%	74%
23	85%	99%	77%
24	89%	100%	77%
25	93%	100%	77%
26	96%	100%	80%
27	100%	100%	80%

Table A29 Continued.

Longline catcher-processor 1991

Cum # of ves	Cum % of ves	% cod value	Cum % cod value
1	3%	0%	0%
2	5%	0%	0%
3	8%	0%	0%
4	11%	3%	0%
5	14%	9%	1%
6	16%	18%	1%
7	19%	42%	3%
8	22%	43%	8%
9	24%	47%	12%
10	27%	65%	14%
11	30%	65%	19%
12	32%	76%	22%
13	35%	77%	23%
14	38%	81%	24%
15	41%	85%	30%
16	43%	90%	30%
17	46%	93%	32%
18	49%	99%	37%
19	51%	100%	45%
20	54%	100%	46%
21	57%	100%	50%
22	59%	100%	50%
23	62%	100%	51%
24	65%	100%	53%
25	68%	100%	53%
26	70%	100%	55%
27	73%	100%	58%
28	76%	100%	61%
29	78%	100%	61%
30	81%	100%	63%
31	84%	100%	63%
32	86%	100%	64%
33	89%	100%	65%
34	92%	100%	65%
35	95%	100%	65%
36	97%	100%	66%
37	100%	100%	67%

Table A29 Continued.

Longline catcher-processor 1992

Cum # of ves	Cum % of ves	% cod value	Cum % cod value
1	2%	0%	0%
2	4%	1%	0%
3	6%	2%	1%
4	7%	2%	1%
5	9%	3%	1%
6	11%	5%	3%
7	13%	7%	3%
8	15%	17%	3%
9	17%	21%	3%
10	19%	27%	4%
11	20%	30%	8%
12	22%	31%	11%
13	24%	38%	13%
14	26%	38%	15%
15	28%	39%	15%
16	30%	40%	16%
17	31%	43%	17%
18	33%	44%	17%
19	35%	48%	18%
20	37%	55%	19%
21	39%	59%	20%
22	41%	62%	22%
23	43%	67%	24%
24	44%	68%	24%
25	46%	75%	26%
26	48%	77%	28%
27	50%	77%	29%
28	52%	78%	30%
29	54%	79%	30%
30	56%	84%	32%
31	57%	85%	33%
32	59%	86%	35%
33	61%	87%	37%
34	63%	91%	38%
35	65%	91%	39%
36	67%	94%	42%
37	69%	96%	44%
38	70%	97%	45%
39	72%	98%	46%
40	74%	99%	49%
41	76%	99%	49%
42	78%	99%	51%
43	80%	99%	51%
44	81%	100%	51%
45	83%	100%	52%
46	85%	100%	53%
47	87%	100%	54%
48	89%	100%	55%
49	91%	100%	56%
50	93%	100%	57%
51	94%	100%	58%
52	96%	100%	59%
53	98%	100%	60%
54	100%	100%	61%

Table A29 Continued.

Trawl catcher-processor 1990

Cum # of ves	Cum % of ves	% cod value	Cum % cod value
1	3%	0%	0%
2	5%	0%	0%
3	8%	1%	0%
4	10%	1%	1%
5	13%	1%	1%
6	15%	2%	1%
7	18%	2%	1%
8	20%	4%	1%
9	23%	4%	2%
10	25%	6%	2%
11	28%	7%	2%
12	30%	7%	2%
13	33%	8%	3%
14	35%	10%	3%
15	38%	12%	4%
16	40%	12%	5%
17	43%	12%	5%
18	45%	13%	5%
19	48%	14%	6%
20	50%	14%	6%
21	53%	20%	7%
22	55%	22%	7%
23	58%	23%	8%
24	60%	32%	8%
25	63%	33%	9%
26	65%	34%	10%
27	68%	35%	10%
28	70%	40%	11%
29	73%	46%	12%
30	75%	47%	12%
31	78%	47%	13%
32	80%	48%	14%
33	83%	49%	14%
34	85%	51%	15%
35	88%	51%	15%
36	90%	56%	16%
37	93%	57%	17%
38	95%	62%	17%
39	98%	91%	18%
40	100%	100%	18%

Table A29 Continued.

Trawl catcher-processor 1991

Cum # of ves	Cum % of ves	% cod value	Cum % cod value
1	2%	0%	0%
2	4%	0%	0%
3	6%	0%	0%
4	8%	0%	0%
5	10%	0%	0%
6	12%	0%	0%
7	14%	1%	0%
8	16%	1%	0%
9	18%	1%	0%
10	20%	1%	1%
11	22%	3%	1%
12	24%	3%	1%
13	25%	3%	1%
14	27%	4%	1%
15	29%	4%	2%
16	31%	4%	2%
17	33%	4%	2%
18	35%	4%	2%
19	37%	5%	2%
20	39%	5%	2%
21	41%	5%	2%
22	43%	5%	3%
23	45%	5%	3%
24	47%	5%	3%
25	49%	6%	3%
26	51%	6%	3%
27	53%	6%	3%
28	55%	6%	3%
29	57%	7%	3%
30	59%	8%	3%
31	61%	8%	3%
32	63%	10%	3%
33	65%	10%	4%
34	67%	10%	4%
35	69%	11%	4%
36	71%	12%	4%
37	73%	12%	4%
38	75%	13%	4%
39	76%	13%	4%
40	78%	16%	4%
41	80%	17%	5%
42	82%	17%	5%
43	84%	19%	5%
44	86%	21%	5%
45	88%	24%	5%
46	90%	25%	6%
47	92%	27%	6%
48	94%	45%	6%
49	96%	79%	6%
50	98%	94%	6%
51	100%	99%	7%

Table A29 Continued.

Trawl catcher-processor 1992

Cum # of ves	Cum % of ves	% cod value	Cum % cod value
1	2%	0%	0%
2	4%	0%	0%
3	7%	0%	0%
4	9%	0%	0%
5	11%	0%	0%
6	13%	0%	0%
7	16%	0%	0%
8	18%	1%	0%
9	20%	1%	0%
10	22%	2%	0%
11	24%	2%	0%
12	27%	2%	0%
13	29%	3%	0%
14	31%	3%	1%
15	33%	4%	1%
16	36%	4%	1%
17	38%	4%	1%
18	40%	4%	1%
19	42%	5%	1%
20	44%	5%	2%
21	47%	6%	2%
22	49%	6%	2%
23	51%	6%	2%
24	53%	7%	3%
25	56%	8%	3%
26	58%	9%	3%
27	60%	9%	3%
28	62%	9%	3%
29	64%	10%	4%
30	67%	11%	4%
31	69%	12%	5%
32	71%	12%	5%
33	73%	12%	5%
34	76%	13%	6%
35	78%	13%	6%
36	80%	14%	6%
37	82%	16%	6%
38	84%	16%	6%
39	87%	17%	7%
40	89%	18%	7%
41	91%	19%	7%
42	93%	22%	7%
43	96%	22%	7%
44	98%	28%	8%
45	100%	29%	8%

Source: 1990-91 NMFS Alaska Region weekly processor data, 1992 NMFS Alaska Region product data.

Table A30 Dependency in terms of weeks fished of catcher boats on the BSAI cod fisheries by gear, 1991-92.

Longline catcher boats 1991 and 1992

Cum # of ves	Cum % of ves	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	Cum % cod weeks
1991 1	1%	1	17	6%	1	17	6%
6	5%	1	10	10%	6	80	8%
12	10%	1	8	13%	12	134	9%
19	15%	1	7	14%	19	184	10%
25	20%	1	6	17%	27	232	12%
31	25%	2	11	18%	39	301	13%
37	30%	2	10	20%	48	346	14%
43	35%	1	4	25%	58	391	15%
49	40%	2	7	29%	69	431	16%
55	45%	1	3	33%	81	469	17%
62	50%	2	5	40%	93	502	19%
68	55%	4	9	44%	112	547	20%
74	60%	1	2	50%	126	576	22%
80	65%	4	7	57%	145	610	24%
86	70%	2	3	67%	165	642	26%
92	75%	7	8	88%	187	671	28%
99	80%	10	10	100%	219	704	31%
105	85%	2	2	100%	227	712	32%
111	90%	1	1	100%	243	728	33%
117	95%	1	1	100%	253	738	34%
123	100%	9	9	100%	267	752	36%
1992 1	1%	1	11	9%	1	11	9%
4	5%	1	9	11%	4	40	10%
9	10%	1	7	14%	9	80	11%
13	15%	1	6	17%	14	111	13%
18	21%	1	5	20%	21	148	14%
22	26%	2	9	22%	27	176	15%
26	30%	1	4	25%	33	200	17%
30	35%	2	7	29%	41	229	18%
34	40%	1	3	33%	52	262	20%
39	45%	5	14	36%	69	312	22%
43	50%	2	5	40%	81	344	24%
47	55%	1	2	50%	92	369	25%
52	60%	9	17	53%	106	396	27%
56	65%	3	5	60%	119	418	28%
60	70%	3	4	75%	138	445	31%
65	76%	2	2	100%	157	467	34%
69	80%	1	1	100%	162	472	34%
73	85%	2	2	100%	167	477	35%
77	90%	2	2	100%	174	484	36%
82	95%	2	2	100%	185	495	37%
86	100%	4	4	100%	194	504	38%

Table A30 Dependency of catcher boats on the BSAI cod fisheries in terms of weeks fished by gear, 1991-92.

Longline catcher boats 1991

Cum # of vessels	Cum % vessels	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	% Cum cod weeks
1	1%	1	21	5%	1	21	5%
6	5%	1	10	10%	6	89	7%
12	10%	1	8	13%	12	145	8%
18	15%	1	7	14%	19	198	10%
25	20%	2	12	17%	28	254	11%
31	25%	2	12	17%	37	308	12%
37	30%	2	10	20%	48	365	13%
43	35%	2	9	22%	58	413	14%
49	40%	3	11	27%	70	459	15%
55	45%	2	6	33%	82	498	16%
68	55%	2	5	40%	115	587	20%
74	60%	4	9	44%	139	642	22%
80	65%	1	2	50%	155	674	23%
86	70%	2	3	67%	174	706	25%
92	75%	3	4	75%	190	729	26%
98	80%	1	1	100%	212	754	28%
105	85%	2	2	100%	237	779	30%
111	90%	1	1	100%	243	785	31%
117	95%	1	1	100%	253	795	32%
123	100%	9	9	100%	267	809	33%

Longline catcher boats 1992

Cum # of vessels	Cum % vessels	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	% Cum cod weeks
1	1%	1	24	4%	1	24	4%
4	5%	1	10	10%	5	65	8%
9	10%	1	8	13%	10	108	9%
13	15%	1	7	14%	14	137	10%
17	20%	1	6	17%	19	167	11%
22	25%	1	5	20%	26	204	13%
26	30%	2	9	22%	34	241	14%
30	34%	2	8	25%	44	282	16%
35	40%	2	6	33%	53	313	17%
39	45%	4	12	33%	66	352	19%
43	49%	3	8	38%	84	402	21%
48	55%	3	7	43%	101	444	23%
52	60%	1	2	50%	107	456	23%
57	66%	9	17	53%	120	481	25%
61	70%	3	5	60%	133	503	26%
65	75%	11	15	73%	150	527	28%
70	80%	1	1	100%	166	546	30%
74	85%	1	1	100%	171	551	31%
78	90%	2	2	100%	176	556	32%
83	95%	2	2	100%	186	566	33%
87	100%	4	4	100%	197	577	34%

Table A30 (Continued).

Trawl catcher boats 1991

Cum # of vessels	Cum % vessels	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	% Cum cod weeks
1	2%	1	28	4%	1	28	4%
3	5%	1	20	5%	3	76	4%
6	10%	2	25	8%	7	132	5%
9	15%	3	28	11%	15	214	7%
12	20%	2	16	13%	21	262	8%
15	25%	5	33	15%	32	340	9%
18	31%	7	38	18%	47	423	11%
21	36%	2	10	20%	61	495	12%
24	41%	7	30	23%	82	592	14%
27	46%	1	4	25%	97	656	15%
32	54%	9	23	39%	134	776	17%
35	59%	5	12	42%	156	831	19%
38	64%	16	36	44%	193	915	21%
41	69%	1	2	50%	210	952	22%
44	75%	6	8	75%	232	988	23%
47	80%	14	15	93%	261	1,021	26%
50	85%	1	1	100%	268	1,028	26%
53	90%	16	16	100%	300	1,060	28%
56	95%	1	1	100%	313	1,073	29%
59	100%	15	15	100%	341	1,101	31%

Trawl catcher boats 1992

Cum # of vessels	Cum % vessels	BSAI cod weeks	Alaska gf weeks	% cod weeks	Cum BSAI cod weeks	Cum Alaska gf weeks	% Cum cod weeks
1	2%	1	29	3%	1	29	3%
3	5%	1	27	4%	3	84	4%
7	11%	1	25	4%	7	188	4%
10	15%	1	24	4%	10	261	4%
13	20%	1	20	5%	13	321	4%
16	24%	2	27	7%	18	389	5%
20	30%	1	11	9%	24	462	5%
23	35%	3	28	11%	32	541	6%
26	39%	3	27	11%	38	595	6%
30	45%	1	7	14%	46	656	7%
33	50%	2	12	17%	53	700	8%
36	55%	3	16	19%	65	767	8%
40	61%	7	33	21%	85	866	10%
43	65%	9	31	29%	102	932	11%
46	70%	13	33	39%	130	1,009	13%
49	74%	13	29	45%	152	1,059	14%
53	80%	5	10	50%	171	1,098	16%
56	85%	10	12	83%	187	1,121	17%
59	89%	12	14	86%	223	1,163	19%
63	95%	1	1	100%	249	1,192	21%
66	100%	1	1	100%	252	1,195	21%

Source: ADF&G Fish tickets data.

Note: Observations were taken at approximately 5% intervals.

Table A31 Dependency of catcher boats on the BSAI cod fisheries in terms of product value by gear, 1991-92.

Longline catcher boats 1991

Cum # of vessels	Cum % of vessels	% cod value	Cum % cod value
1	1%	0%	0%
6	5%	0%	0%
12	10%	1%	0%
18	15%	2%	1%
25	20%	3%	1%
31	25%	5%	2%
37	30%	6%	3%
43	35%	7%	3%
49	40%	11%	4%
55	45%	14%	5%
68	55%	27%	8%
74	60%	37%	9%
80	65%	55%	10%
86	70%	70%	11%
92	75%	88%	12%
98	80%	100%	14%
105	85%	100%	15%
111	90%	100%	15%
117	95%	100%	18%
123	100%	100%	21%

Longline catcher boats 1992

Cum # of vessels	Cum % of vessels	% cod value	Cum % cod value
1	1%	0%	0%
4	5%	1%	0%
9	10%	2%	1%
13	15%	2%	1%
17	20%	3%	1%
22	25%	5%	1%
26	30%	9%	2%
30	34%	10%	2%
35	40%	13%	3%
39	45%	17%	4%
43	49%	23%	4%
48	55%	31%	7%
52	60%	34%	8%
57	66%	51%	11%
61	70%	59%	14%
65	75%	73%	15%
70	80%	100%	17%
74	85%	100%	20%
78	90%	100%	21%
83	95%	100%	27%
87	100%	100%	30%

Table A31 (Continued).

Trawl catcher boats 1991

Cum # of vessels	Cum % of vessels	% cod value	Cum % cod value
1	2%	0%	0%
3	5%	1%	1%
6	10%	2%	1%
9	15%	5%	3%
12	20%	7%	4%
15	25%	9%	4%
18	31%	10%	6%
21	36%	11%	7%
24	41%	14%	7%
27	46%	17%	8%
32	54%	35%	10%
35	59%	39%	10%
38	64%	47%	12%
41	69%	63%	13%
44	75%	79%	13%
47	80%	88%	15%
50	85%	100%	16%
53	90%	100%	16%
56	95%	100%	17%
59	100%	100%	18%

Trawl catcher boats 1992

Cum # of vessels	Cum % of vessels	% cod value	Cum % cod value
1	2%	0%	0%
3	5%	0%	0%
7	11%	0%	0%
10	15%	1%	0%
13	20%	1%	0%
16	24%	1%	0%
20	30%	2%	1%
23	35%	2%	1%
26	39%	3%	1%
30	45%	5%	1%
33	50%	6%	2%
36	55%	7%	2%
40	61%	14%	2%
43	65%	21%	3%
46	70%	22%	3%
49	74%	33%	4%
53	80%	58%	5%
56	85%	75%	6%
59	89%	80%	7%
63	95%	100%	7%
66	100%	100%	7%

Source: ADF&G Fish tickets data.

Note: Observations were taken at approximately 5% intervals.

Table A32 Numbers and mean lengths of domestic BSAI cod fishery catcher-processors by gear group and gear group combination, 1990-92.

Number of catcher-processors

	1990	1991	1992
Longline	27	37	54
Pot	5	8	19
Trawl	40	51	45
Longline only	27	32	41
Pot only	5	6	15
Trawl only	40	46	32
Longline & pot	0	1	1
Longline & trawl	0	4	10
Pot & trawl	0	1	1
Longline, pot, & trawl	0	0	2
Total	72	90	102

Mean length of catcher-processors

	1990	1991	1992
Longline	127	134	135
Pot	163	155	160
Trawl	170	192	173
Longline only	127	133	132
Pot only	163	166	163
Trawl only	170	198	188
Longline & pot	.	102	180
Longline & trawl	.	144	136
Pot & trawl	.	150	81
Longline, pot, & trawl	.	.	173

Sources: Weekly processor report data and State of Alaska vessel registration file.

Table A33 U.S. and Japanese cod prices, monthly, 1989-92 in $/lb.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Cod fillets, 5 lb, Canada, FOB East Coast												
1989	1.62	1.65	1.72	1.65	1.62	1.58	1.60	1.65	1.72	1.78	1.78	1.75
1990	1.75	1.75	1.85	1.92	2.00	2.10	2.10	2.25	2.32	2.52	2.72	2.62
1991	2.65	2.62	2.62	2.62	2.60	2.48	2.40	2.35	2.48	2.48	2.45	2.38
1992	2.35	2.32	2.35	2.40	2.40	2.32	2.38	2.45	2.48	2.50	2.38	2.35
Cod fillets, 5 lb, Iceland, FOB East Coast												
1989	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
1990	2.30	2.30	2.30	2.30	2.30	2.30	2.40	2.60	2.80	2.95	2.95	2.95
1991	3.10	3.20	3.20	3.20	3.20	3.20	3.10	3.10	3.10	3.10	3.10	3.10
1992	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10	3.10
Cod fillets, 8-16 oz, shatter pack, FOB Seattle												
1989	1.89	2.02	2.00	2.00	2.09	2.05	1.94	1.98	1.98	2.02	1.86	1.88
1990	1.90	1.92	1.93	1.96	2.02	2.20	2.32	2.46	2.65	2.75	2.74	2.80
1991	2.80	2.81	2.81	2.80	2.75	2.71	2.69	2.59	2.55	2.59	2.56	2.60
1992	2.55	2.50	2.60	2.70	2.70	2.60	2.60	2.60	2.55	2.62	2.60	2.60
Cod fillets, 16-32 oz, shatter pack, FOB Seattle												
1989	1.94	2.08	2.08	2.08	2.17	2.12	2.09	2.08	2.08	2.08	1.92	1.92
1990	1.89	1.90	1.91	1.99	2.04	2.24	2.40	2.53	2.68	2.80	2.80	2.82
1991	2.82	2.85	2.85	2.82	2.78	2.75	2.71	2.62	2.58	2.70	2.75	2.69
1992	2.60	2.55	2.65	2.80	2.78	2.68	2.58	2.58	2.64	2.62	2.62	2.62
Cod, frozen, landing price, Japan												
1989	.96	1.06	1.07	.82	.77	--	.43	.65	.63	1.12	1.21	1.19
1990	1.17	1.33	.97	.99	1.21	--	--	1.15	1.15	--	1.12	1.02
1991	1.12	1.01	1.01	1.10	1.03	1.11	--	1.08	1.32	1.42	1.59	1.56
1992	1.34	1.15	.96	.85	.92	.96	1.08	1.16	1.24	1.28		
Cod, frozen, wholesale price, Japan												
1989	1.68	1.60	1.19	2.06	1.73	1.50	1.65	1.95	.54	1.69	1.60	1.82
1990	1.77	1.98	1.85	1.68	1.78	2.00	2.10	2.30	2.31	2.39	2.18	2.46
1991	2.38	2.36	2.29	2.38	2.42	2.25	2.51	2.52	2.63	2.78	2.52	2.63
1992	2.89	2.64	2.65	2.62	2.65	2.65	2.72	2.61	2.67	2.51		

Sources: U.S. prices -- NMFS Fisheries Market News Report.
Japanese prices -- Monthly Statistics of Agriculture, Forestry & Fisheries.

Table A34 Weekly wholesale prices of 8-16 ounce cod fillets and 2-4 ounce pollock fillets, FOB West Coast, 1991-92 (Dollars per pound).

Week ending	Cod, 8-16 ounce 1991	Cod, 8-16 ounce 1992	Pollock 2-4 ounce 1991	Pollock 2-4 ounce 1992
1/03	2.68	2.30	1.65	1.60
1/10	2.68	2.30	1.65	1.60
1/17	2.68	2.30	1.65	1.60
1/24	2.65	2.30	1.65	1.60
1/31	2.65	2.30	1.65	1.60
2/07	2.65	2.30	1.65	1.60
2/14	2.65	2.22	1.65	1.50
2/21	2.65	2.68	1.65	1.50
2/28	2.65	2.68	1.65	1.50
3/06	2.90	2.68	1.88	1.50
3/13	2.90	2.68	1.88	1.50
3/20	2.90	2.68	1.88	1.50
3/27	2.90	2.68	1.88	1.50
4/03	2.85	2.68	1.88	1.50
4/10	2.80	2.82	1.80	1.50
4/17	2.80	2.82	1.80	1.50
4/24	2.80	2.82	1.80	1.50
5/01	2.75	2.62	1.80	1.50
5/08	2.75	2.62	1.80	1.50
5/15	2.75	2.62	1.70	1.50
5/22	2.75	2.62	1.70	1.50
5/29	2.75	2.62	1.70	1.50
6/05	2.72	2.62	1.70	1.50
6/12	2.72	2.62	1.70	1.50
6/19	2.68	2.62	1.58	1.50
6/26	2.68	2.55	1.55	1.50
7/03	2.68	2.55	1.55	1.50
7/10	2.68	2.55	1.55	1.50
7/17	2.65	2.55	1.50	1.50
7/24	2.65	2.55	1.50	1.50
7/31	2.65	2.55	1.50	1.50
8/07	2.65	2.55	1.50	1.50
8/14	2.65	2.55	1.50	1.50
8/21	2.55	2.55	1.50	1.50
8/28	2.55	2.55	1.62	1.50
9/04	2.55	2.55	1.62	1.50
9/11	2.58	2.55	1.62	1.50
9/18	2.62	2.55	1.62	1.50
9/25	2.62	2.75	1.62	1.30
10/02	2.62	2.50	1.62	1.30
10/09	2.62	2.40	1.62	1.30
10/16	2.62	2.40	1.62	1.30
10/23	2.62	2.40	1.62	1.30
10/30	2.62	2.50	1.62	1.30
11/06	2.62	2.50	1.62	1.30
11/13	2.72	2.50	1.62	1.30
11/20	2.60	2.50	1.60	1.30
11/27	2.60	2.50	1.60	1.30
12/04	2.60	2.50	1.60	1.30
12/11	2.60	2.50	1.60	1.30
12/18	2.60	2.50	1.60	1.30
12/24	2.60		1.60	
12/31	2.60		1.60	

Source: Urner Barry Seafood Price Current

Table A35 Weighted average Ishinomaki Auction prices for medium sized H&G cod from Alaska by gear.

		Weighted Avg. Price	Cases Sold		Weighted Avg. Price	Weighted Avg. Price				
Year	Mon.	Longline (Yen/kg)	Trawl (Yen/kg)	Longline	Trawl	Exchange (Yen/$)	Longline ($/1b)	Trawl ($/1b)	Longline ($/1b)	Trawl ($/1b)
1990	N	319	284	250	98	133.35	1.09	0.97	0.74	0.66
	D					134.4				
1991	J	386	287	5,331	1,836	131.2	1.34	0.99	0.91	0.67
	F		329		2,748	132		1.13		0.77
	M	399	328	2,996	2,087	141	1.28	1.05	0.87	0.72
	A	326	324	1,272	3,354	137.4	1.08	1.07	0.73	0.73
	M	342	310	5,244	1,611	137.9	1.13	1.02	0.77	0.69
	J	327	323	1,295	893	137.9	1.08	1.06	0.73	0.72
	J		312		441	137.8		1.03		0.70
	A	332	318	1,013	120	137.15	1.10	1.05	0.75	0.72
	S	407	367	466	1,663	132.5	1.39	1.26	0.95	0.85
	O	414	369	3,336	766	130.9	1.44	1.28	0.98	0.87
	N	448	383	1,710	291	130.05	1.56	1.34	1.06	0.91
	D	428		1166		125.2	1.55		1.05	
1992	J					125.7				
	F	416	350	982	383	129.28	1.46	1.23	0.99	0.83
	M	352		250		133.2	1.20		0.81	
	A	360	268	768	1,288	133.5	1.22	0.91	0.83	0.62
	M	290	303	570	409	128.25	1.03	1.07	0.70	0.73
	J	325	284	1,622	606	126.81	1.16	1.01	0.79	0.69
	J	325	268	188	814	125.65	1.17	0.97	0.80	0.66
W.avg.		374	318						0.87	0.73

Table A36 Summary statistics for the regression analysis of monthly fillet and H&G prices for 1987-1992.

```
AUTOREGRESS FILLET ON HG ORDER=1
LEAST SQUARES ESTIMATION              67 OBSERVATIONS

BY COCHRANE-ORCUTT TYPE PROCEDURE WITH CONVERGENCE = 0.00100

 LOG L.F. =   -223.388        AT RHO =      0.98303
```


```
AUTOREGRESS FILLET ON HG ORDER=1
LEAST SQUARES ESTIMATION              67 OBSERVATIONS

BY COCHRANE-ORCUTT TYPE PROCEDURE WITH CONVERGENCE = 0.00100

 LOG L.F. =   -223.388        AT RHO =      0.98303
```


	ESTIMATE	ASYMPTOTIC VARIANCE	ASYMPTOTIC ST.ERROR	ASYMPTOTIC T-RATIO
RHO	0.98303	0.00050	0.02241	43.86762

```
R-SQUARE =   0.9562      R-SQUARE ADJUSTED =    0.9556
VARIANCE OF THE ESTIMATE-SIGMA**2 =   45.155
STANDARD ERROR OF THE ESTIMATE-SIGMA =   6.7197
SUM OF SQUARED ERRORS-SSE=   2935.1
MEAN OF DEPENDENT VARIABLE =   222.01
LOG OF THE LIKELIHOOD FUNCTION = -223.388

MODEL SELECTION TESTS - SEE JUDGE ET.AL.(1985, P.242)
 AKAIKE (1969) FINAL PREDICTION ERROR- FPE =    46.503
   (FPE ALSO KNOWN AS AMEMIYA PREDICTION CRITERION -PC)
 AKAIKE (1973) INFORMATION CRITERION- LOG AIC =   3.8395
 SCHWARZ(1978) CRITERION-LOG SC =   3.9053
MODEL SELECTION TESTS - SEE RAMANATHAN(1989,P.166)
 CRAVEN-WAHBA(1979) GENERALIZED CROSS VALIDATION(1979) -GCV=   46.544
 HANNAN AND QUINN(1979) CRITERION -HQ=   47.729
 RICE (1984) CRITERION-RICE=   46.588
 SHIBATA (1981) CRITERION-SHIBATA=   46.422
 SCHWARTZ (1978) CRITERION-SC=   49.665
 AKAIKE (1974)INFORMATION CRITERION-AIC=   46.502
```

ANALYSIS OF VARIANCE - FROM MEAN

	SS	DF	MS
REGRESSION	64114.	1.	64114.
ERROR	2935.1	65.	45.155
TOTAL	67049.	66.	1015.9

ANALYSIS OF VARIANCE - FROM ZERO

	SS	DF	MS
REGRESSION	0.33666E+07	2.	0.16833E+07
ERROR	2935.1	65.	45.155
TOTAL	0.33695E+07	67.	50291.

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 65 DF	PARTIAL CORR.	STANDARDIZED COEFFICIENT	ELASTICITY AT MEANS
HG	0.21329E-01	0.75729E-01	0.28165	0.0349	0.10861E-01	0.65515E-02
CONSTANT	238.33	29.717	8.0200	0.7052	0.00000E+00	1.0735

Table A37 Annual cod exports from Alaska, Washington, and Oregon by product form and country, 1989-92.

	1989		1990		1991		1992	
Product	Quantity (1000 lbs)	Value ($1000)	Quantity (1000 lbs)	Value ($1000)	Quantity (1000 lbs)	Value ($1000)	Quantity (1000 lbs)	Value ($1000)
Whole or dressed								
Fresh	1,936	$ 2,131	3,612	$ 2,220	1,131	$ 1,807	1,319	$ 1,837
Frozen	39,289	38,452	156,972	113,738	176,092	142,582	122,973	91,857
	41,225	40,583	160,514	115,958	177,223	144,389	124,291	93,694
Fillets								
Frozen	1,126	1,407	2,562	3,007	2,215	2,606	2,756	2,548
Dried	0	0	400	245	0	0	9	13
Salted	12,712	13,439	11,394	14,703	14,986	22,323	1,588	3,192
Total	55,063	$55,429	174,870	$133,913	194,424	$169,318	128,644	99,447

	1989		1990		1991		Jan.-Nov. 1992	
	Quantity (1000 lbs)	Value ($1000)	Quantity (1000 lbs)	Value ($1000)	Quantity (1000 lbs)	Value ($1000)	Quantity (1000 lbs)	Value ($1000)
Whole or dressed, Frozen								
Japan	32,089	35,888	73,428	60,356	70,608	65,296	60,044	50,545
Canada	285	332	657	882	1,773	1,938	1,682	2,270
R.of Korea	5,051	2,178	33,565	16,380	36,010	19,955	24,604	12,298
U.K.	28	31	1,611	1,321	12,401	9,678	13,231	8,904
F.R.G.	109	94	7,802	5,797	5,939	4,355	1,080	814
France	42	43	0	0	0	0	0	0
Norway	3,467	1,875	37,910	27,388	29,194	25,538	2,389	1,709
Portugal	62	47	4,159	2,658	13,536	10,792	18,609	14,032
Denmark	--	--	522	357	5,861	4,511	341	284
Hong Kong	--	--	6	12	21	16	49	153
Italy	--	--	0	0	317	260	0	0
Sweden	--	--	8	21	18	47	98	135
	41,133	40,488	159,668	115,172	176,092	142,582	122,972	91,857

Table A37 (Continued).

Product	1989 Quantity (1000 lbs)	1989 Value ($1000)	1990 Quantity (1000 lbs)	1990 Value ($1000)	1991 Quantity (1000 lbs)	1991 Value ($1000)	1992 Jan.-Nov. Quantity (1000 lbs)	1992 Jan.-Nov. Value ($1000)
Fillets								
Japan	314	482	689	818	354	416	409	627
Canada	196	241	446	625	544	888	0	0
R.of Korea	109	124	573	535	380	382	1,209	730
U.K.	67	82	80	159	0	0	118	172
F.R.G.	383	414	0	0	0	0	0	0
Netherlands	55	61	0	0	0	0	0	0
Norway	0	0	87	74	569	499	39	26
Portugal	0	0	626	727	0	0	43	22
France	--	--	0	0	299	311	640	640
Hong Kong	--	--	0	0	9	22	0	0
Sweden	--	--	11	13	12	27	5	10
Taiwan	--	--	40	44	48	61	0	0
	1,124	1,404	2,552	2,995	2,215	2,606	2,756	2,548
Salted								
Japan	83	98	695	308	3,197	4,390	0	0
Canada	88	94	11	14	3	4	114	105
R.of Korea	23	24	0	0	0	0	0	0
F.R.G.	0	0	132	91	0	0	0	0
Portugal	12,518	13,222	10,556	14,289	11,381	17,296	1,475	3,086
Denmark	--	--	0	0	198	323	0	0
France	--	--	0	0	155	232	0	0
Spain	--	--	0	0	52	78	0	0
	12,712	13,438	11,395	14,702	14,986	22,323	1,588	3,192

Source: U.S. Department of Commerce, Bureau of the Census.
Note: Some 1990 country data was not recorded or was zero.

Table A38 Foreign longline cod fishery in the BSAI, 1981-87.

Metric tons of cod catch

	1981	1982	1983	1984	1985	1986	1987
Jan-May	238	237	1,547	2,793	8,754	7,595	19,383
Jun-Aug	153	71	457	2,039	1,141	342	77
Sep-Dec	169	761	1,249	15,333	19,882	15,957	24,209
Year	561	1,069	3,253	20,166	29,777	23,893	43,669

Cod catch as a percent of total groundfish catch

	1981	1982	1983	1984	1985	1986	1987	All
Jan-May	89%	87%	85%	92%	92%	92%	92%	92%
Jun-Aug	84%	80%	53%	90%	92%	96%	97%	84%
Sep-Dec	85%	68%	80%	90%	88%	89%	87%	88%
Year	86%	72%	77%	90%	89%	90%	90%	89%

Halibut bycatch rate
(halibut as a percent of total groundfish catch)

	1981	1982	1983	1984	1985	1986	1987	All
Jan-May	2.34	2.20	2.67	1.83	2.58	1.56	1.86	2.00
Jun-Aug	.29	1.25	3.41	2.53	1.33	.94	.43	2.14
Sep-Dec	.66	.73	2.25	1.76	2.11	2.83	1.63	2.02
Year	1.25	1.03	2.67	1.85	2.22	2.41	1.73	2.02

Kilograms of cod per hook

	1981	1982	1983	1984	1985	1986	1987	All
Jan-May	.65	.71	.98	1.45	1.69	1.50	1.43	1.45
Jun-Aug	.73	.54	.34	1.27	1.32	1.52	1.81	.97
Sep-Dec	.86	.65	.98	1.22	.91	1.11	.83	.96
Year	.72	.65	.77	1.25	1.06	1.21	1.02	1.08

Metric tons of cod per hachi

	1981	1982	1983	1984	1985	1986	1987	All
Jan-May	.02	.03	.04	.06	.07	.06	.06	.06
Jun-Aug	.03	.02	.02	.05	.05	.06	.07	.04
Sep-Dec	.03	.02	.04	.05	.03	.04	.03	.04
Year	.03	.02	.03	.05	.04	.05	.04	.04

Source: Norpac data.

Table A39 Joint venture cod trawl fishery catch, bycatch rates, and catch per unit of effort by season, 1981-89.

Metric tons of cod catch.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	1,063	631	8,232	5,294	6,552	11,356	36,720	19,295	89,143
Jun-Aug	77	949	1,097	495	353	481	2,036	542	.	6,029
Sep-Dec	21	.	.	118	14	158	99	1,463	523	2,395
Year	98	2,012	1,728	8,845	5,661	7,191	13,491	38,724	19,818	97,567

Cod catch as a percent of total groundfish catch.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	81%	78%	80%	84%	82%	88%	87%	86%	86%
Jun-Aug	68%	70%	70%	70%	74%	71%	80%	75%	.	74%
Sep-Dec	78%	.	.	63%	67%	66%	74%	83%	84%	80%
Year	70%	75%	72%	79%	83%	81%	87%	87%	86%	85%

Halibut bycatch rate.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	1.35	1.14	.70	.64	.85	.53	1.09	.87	.89
Jun-Aug	.13	1.17	.61	1.52	.59	.46	.61	.59	.	.76
Sep-Dec	.00	.	.	.44	.84	.30	.96	1.95	.10	1.27
Year	.11	1.26	.79	.75	.64	.81	.55	1.12	.85	.89

Herring bycatch rate.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	.00	.00	.00	.00	.00	.00	.00	.00	.00
Jun-Aug	.01	.00	.00	.03	.07	.02	.01	.01	.	.01
Sep-Dec	.00	.	.	.00	.00	1.32	.00	.00	.04	.12
Year	.01	.00	.00	.00	.01	.04	.00	.00	.00	.00

Red king crab bycatch rate.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	.00	.00	1.11	.06	3.98	.35	.12	.13	.54
Jun-Aug	15.59	5.48	16.10	12.95	67.85	.00	.47	.00	.	9.45
Sep-Dec	1332.44	.	.	237.65	.00	197.86	.00	.00	.00	42.67
Year	270.47	2.78	10.65	5.81	4.80	8.86	.37	.11	.13	2.27

Table A39 (Continued).

Bairdi crab bycatch rate.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	4.10	594.09	272.97	194.05	508.94	263.74	96.10	145.32	185.29
Jun-Aug	.00	.00	2.22	9.31	14.90	45.73	.00	33.66	.	8.85
Sep-Dec	328.44	.	.	69.95	57.63	39.37	.00	113.15	11.65	79.89
Year	63.57	2.02	202.70	252.96	181.11	461.27	218.20	95.76	141.70	170.03

Chinook bycatch rate.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	.02	.00	.00	.00	.00	.00	.00	.00	.00
Jun-Aug	.00	.00	.00	.00	.00	.00	.00	.00	.	.00
Sep-Dec	.00	.	.	.00	.00	.00	.00	.00	.00	.00
Year	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00

Salmon bycatch rate.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	.00	.00	.00	.00	.00	.00	.00	.00	.00
Jun-Aug	.00	.00	.00	.00	.00	.00	.00	.00	.	.00
Sep-Dec	.00	.	.	.00	.00	.00	.00	.00	.00	.00
Year	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

Metric tons of cod per hour.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May	.	.	.	13	4	4	5	6	5	.
Jun-Aug	.	.	.	6	2	4	4	5	.	.
Sep-Dec	.	.	.	6	1	4	3	3	11	.
Year	.	.	.	12	3	4	5	6	6	.

Metric tons of cod per haul.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	All
Jan-May										
Jun-Aug	THIS CPUE DATA IS BEING PREPARED									
Sep-Dec										
Year										

Source: Norpac data.

Table A40 Mean wave height (meters) and mean wind speed (knots) in the Bering Sea by area, monthly.

	Mean wave height		Mean wind speed	
	Area B	Area C	Area B	Area C
Jan.	2.0	1.8	19.6	19.0
Feb.	1.8	1.7	20.2	19.4
Mar.	1.6	1.5	18.8	16.7
Apr.	1.4	1.4	17.5	16.7
May	1.1	1.0	14.1	13.7
June	0.9	0.9	12.4	11.8
July	0.9	0.9	12.9	11.8
Aug.	1.1	1.1	15.1	13.6
Sep.	1.4	1.3	15.9	16.0
Oct.	1.8	1.6	19.7	18.9
Nov.	2.0	1.9	19.2	19.9
Dec.	2.0	1.8	19.3	18.6

Source: Bower, W.A., et al. 1988. Climatic Atlas of the outer continental shelf waters and coastal regions of Alaska, Vol. II, Bering Sea. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK and U.S. National Climatic Data Center, Asheville, NC.

Table A41 Percent of wave height greater than 4 and 6 meters in the Bering Sea by area, monthly.

	Area B		Area C	
	>4 meters	>6 meters	>4 meters	>6 meters
Jan.	16.5	2.9	12.0	2.4
Feb.	12.7	2.6	10.6	1.3
Mar.	10.1	2.2	6.0	1.3
Apr.	8.6	2.3	7.0	1.4
May	2.5	0.4	2.8	0.4
June	1.3	0.0	1.3	0.0
July	0.8	0.1	0.8	0.1
Aug.	4.5	1.6	1.7	0.3
Sep.	8.9	2.8	5.1	0.9
Oct.	14.5	3.9	10.8	2.2
Nov.	15.4	3.6	16.2	3.5
Dec.	15.5	4.1	11.5	2.1

Source: Bower, W.A., et al. 1988. Climatic Atlas of the outer continental shelf waters and coastal regions of Alaska, Vol. II, Bering Sea. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK and U.S. National Climatic Data Center, Asheville, NC.

Table A42 Percent of winds greater than 28 and 41 knots in the Bering Sea by area, monthly.

	Area B		Area C	
	>28 knots	>41 knots	>28 knots	>41 knots
Jan.	17	1	18	1
Feb.	21	3	20	2
Mar.	14	1	12	1
Apr.	12	1	10	0
May	4	0	6	1
June	2	0	4	1
July	1	0	3	1
Aug.	6	0	5	0
Sep.	10	0	11	1
Oct.	19	1	17	1
Nov.	18	3	20	3
Dec.	18	3	18	1

Source: Bower, W.A., et al. 1988. Climatic Atlas of the outer continental shelf waters and coastal regions of Alaska, Vol. II, Bering Sea. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK and U.S. National Climatic Data Center, Asheville, NC.

Figure A1

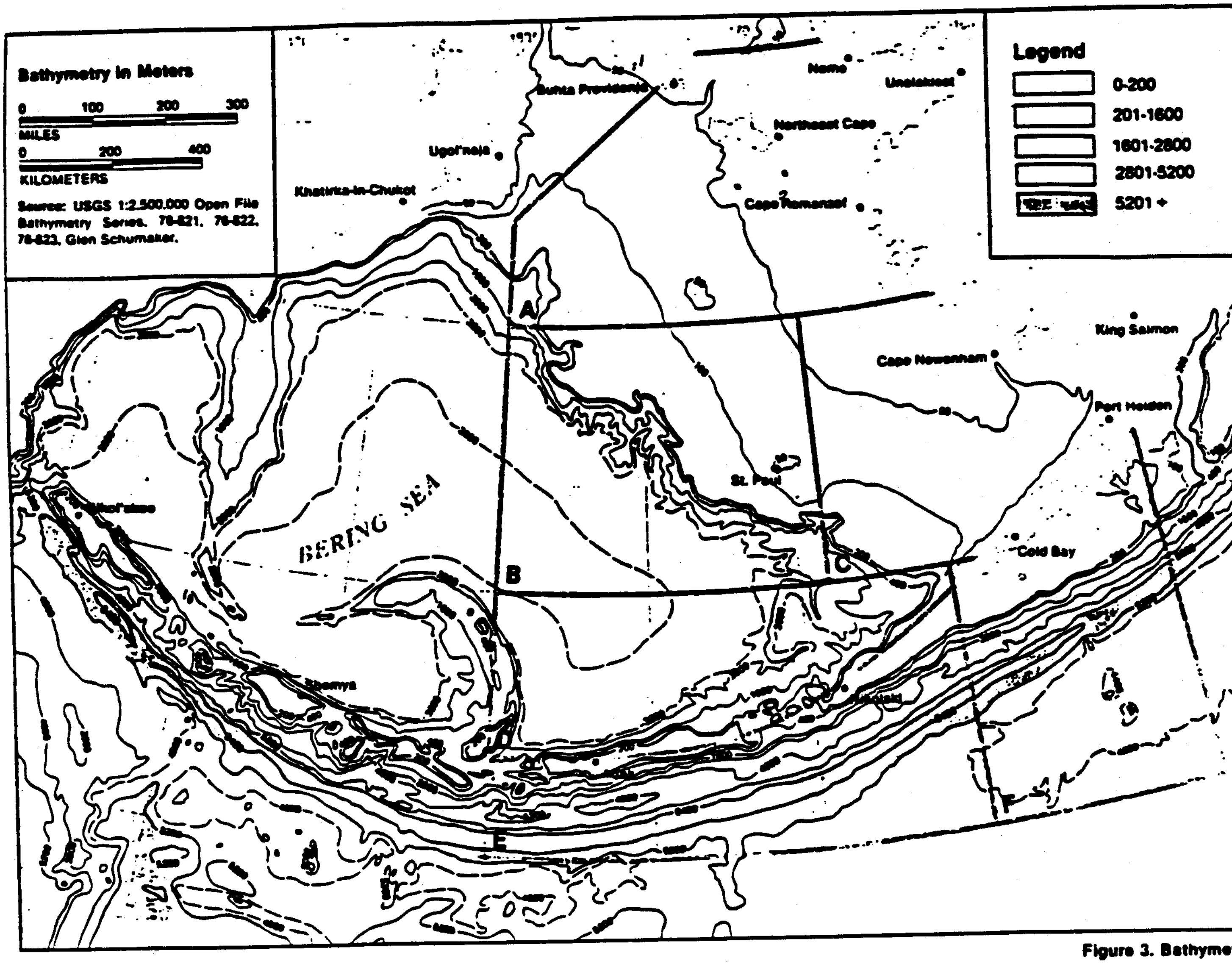

Figure 3. Bathyme

Table A43 Average gross revenue (value) per metric ton of cod catch by fishery and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline	$845	$784	$722	$784
Pot	.	$671	$749	$710
Trawl	$1,194	.	.	$1,194
1992				
Longline	$777	$704	$772	$749
Pot	$1,017	$658	$768	$765
Trawl	$1,139	.	.	$1,139
1991-92 average				
Longline	$800	$733	$731	$764
Pot	$1,017	$662	$752	$748
Trawl	$1,175	.	.	$1,175

Note: The annual estimates exclude second and third trimester data for the 1991 and 1992 cod trawl fishery and first trimester data for the 1991 cod pot fishery because there was not enough catch for that data to be meaningful.

Table A44 Variability in the estimates average gross revenue (value) per metric ton of cod catch by fishery and and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline				
Min	$651	$517	$178	$178
Max	$2,294	$4,013	$1,627	$3,261
Stdev	$299	$823	$247	$615
Pot				
Min	.	$446	$546	$506
Max	.	$1,708	$1,377	$1,708
Stdev	.	$526	$264	$406
Trawl				
Min	$252	.	.	$252
Max	$2,717	.	.	$2,717
Stdev	$433	.	.	$433
1992				
Longline				
Min	$479	$478	$368	$539
Max	$5,275	$3,212	$2,657	$4,564
Stdev	$696	$589	$388	$645
Pot				
Min	$520	$256	$641	$256
Max	$2,409	$1,737	$940	$2,336
Stdev	$496	$336	$74	$388
Trawl				
Min	$266	.	.	$266
Max	$3,417	.	.	$3,417
Stdev	$531	.	.	$531
1991-92 average				
Longline				
Min	$479	$542	$279	$507
Max	$4,359	$3,773	$2,657	$3,558
Stdev	$585	$694	$343	$595
Pot				
Min	$520	$256	$571	$256
Max	$2,409	$1,716	$1,377	$2,192
Stdev	$496	$345	$207	$364
Trawl				
Min	$274	.	.	$274
Max	$3,417	.	.	$3,417
Stdev	$475	.	.	$475

Note: The annual estimates exclude second and third trimester data for the 1991 and 1992 cod trawl fishery and first trimester dota for the 1991 cod pot fishery because there was not enough catch for that data to be meaningful.

Table A45 Three sets of estimates of variable harvesting and processing cost per metric ton of cod catch by type of operation and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1	$476	$471	$473	$473
2	$509	$548	$552	$535
3	$546	$562	$566	$558
Pot 1	.	$295	$386	$342
2	.	$336	$432	$386
3	.	$378	$479	$430
Fillet trawl 1	$588	.	.	$588
2	$661	.	.	$661
3	$735	.	.	$735
H & G trawl 1	$462	.	.	$462
2	$530	.	.	$530
3	$598	.	.	$598
All trawl 1	$530	.	.	$530
2	$601	.	.	$601
3	$672	.	.	$672
1992				
Longline 1	$445	$474	$556	$463
2	$483	$560	$676	$524
3	$515	$571	$678	$546
Pot 1	$377	$438	$748	$441
2	$431	$513	$907	$516
3	$485	$588	$1,067	$591
Fillet trawl 1	$553	.	.	$553
2	$621	.	.	$621
3	$690	.	.	$690
H & G trawl 1	$416	.	.	$416
2	$481	.	.	$481
3	$547	.	.	$547
All trawl 1	$510	.	.	$510
2	$577	.	.	$577
3	$645	.	.	$645
1991-92 average				
Longline 1	$455	$473	$488	$467
2	$492	$556	$575	$529
3	$525	$568	$587	$551
Pot 1	$377	$403	$447	$408
2	$431	$470	$512	$473
3	$485	$536	$578	$538
Fillet trawl 1	$571	.	.	$571
2	$641	.	.	$641
3	$712	.	.	$712
H & G trawl 1	$446	.	.	$446
2	$513	.	.	$513
3	$580	.	.	$580
All trawl 1	$521	.	.	$521
2	$590	.	.	$590
3	$660	.	.	$660

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A46 Variability of variable cost estimates among individual operations by type of operation and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1				
Min	$385	$359	$128	$128
Max	$2,119	$2,007	$6,537	$6,537
Stdev	$489	$412	$1,443	$1,323
2				
Min	$358	$394	$130	$130
Max	$2,828	$2,849	$10,999	$10,999
Stdev	$766	$656	$2,515	$2,291
3				
Min	$421	$419	$144	$144
Max	$2,713	$2,653	$9,481	$9,481
Stdev	$680	$579	$2,135	$1,950
Pot 1				
Min	.	$225	$281	$270
Max	.	$1,129	$799	$1,063
Stdev	.	$379	$195	$300
2				
Min	.	$247	$310	$301
Max	.	$1,420	$965	$1,329
Stdev	.	$493	$248	$392
3				
Min	.	$269	$339	$331
Max	.	$1,710	$1,131	$1,595
Stdev	.	$607	$301	$486
Fillet trawl 1				
Min	$342	.	.	$342
Max	$1,556	.	.	$1,556
Stdev	$360	.	.	$360
2				
Min	$386	.	.	$386
Max	$1,918	.	.	$1,918
Stdev	$438	.	.	$438
3				
Min	$430	.	.	$430
Max	$2,280	.	.	$2,280
Stdev	$518	.	.	$518
H & G trawl 1				
Min	$226	.	.	$226
Max	$1,827	.	.	$1,827
Stdev	$292	.	.	$292
2				
Min	$249	.	.	$249
Max	$2,290	.	.	$2,290
Stdev	$369	.	.	$369
3				
Min	$272	.	.	$272
Max	$2,753	.	.	$2,753
Stdev	$448	.	.	$448
All trawl 1				
Min	$226	.	.	$226
Max	$1,827	.	.	$1,827
Stdev	$298	.	.	$298
2				
Min	$249	.	.	$249
Max	$2,290	.	.	$2,290
Stdev	$369	.	.	$369
3				
Min	$272	.	.	$272
Max	$2,753	.	.	$2,753
Stdev	$442	.	.	$442

Table A46 Continued.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1992				
Longline 1				
Min	$367	$338	$272	$361
Max	$2,673	$10,658	$3,055	$10,658
Stdev	$405	$1,641	$590	$1,531
2				
Min	$371	$320	$334	$375
Max	$4,351	$17,314	$4,780	$17,314
Stdev	$693	$2,718	$930	$2,530
3				
Min	$411	$369	$334	$413
Max	$3,804	$15,155	$4,254	$15,155
Stdev	$593	$2,359	$824	$2,197
Pot 1				
Min	$254	$240	$509	$240
Max	$2,528	$696	$2,538	$2,538
Stdev	$752	$124	$673	$651
2				
Min	$277	$289	$588	$289
Max	$3,290	$843	$3,280	$3,290
Stdev	$1,000	$156	$893	$861
3				
Min	$301	$339	$666	$339
Max	$4,051	$989	$4,021	$4,051
Stdev	$1,248	$188	$1,113	$1,072
Fillet trawl 1				
Min	$412	.	.	$412
Max	$991	.	.	$991
Stdev	$194	.	.	$194
2				
Min	$449	.	.	$449
Max	$1,181	.	.	$1,181
Stdev	$236	.	.	$236
3				
Min	$482	.	.	$482
Max	$1,371	.	.	$1,371
Stdev	$281	.	.	$281
H & G trawl 1				
Min	$218	.	.	$218
Max	$11,520	.	.	$11,520
Stdev	$2,594	.	.	$2,594
2				
Min	$256	.	.	$256
Max	$15,282	.	.	$15,282
Stdev	$3,459	.	.	$3,459
3				
Min	$275	.	.	$275
Max	$19,045	.	.	$19,045
Stdev	$4,325	.	.	$4,325
All trawl 1				
Min	$218	.	.	$218
Max	$11,520	.	.	$11,520
Stdev	$2,140	.	.	$2,140
2				
Min	$269	.	.	$269
Max	$15,282	.	.	$15,282
Stdev	$2,856	.	.	$2,856
3				
Min	$320	.	.	$320
Max	$19,045	.	.	$19,045
Stdev	$3,573	.	.	$3,573

Table A46 Continued.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991-92 average				
Longline 1				
Min	$370	$338	$146	$262
Max	$2,673	$10,658	$6,537	$10,658
Stdev	$480	$1,571	$1,053	$1,448
2				
Min	$373	$367	$149	$263
Max	$4,351	$17,314	$10,999	$17,314
Stdev	$786	$2,598	$1,789	$2,379
3				
Min	$414	$390	$164	$292
Max	$3,804	$15,155	$9,481	$15,155
Stdev	$685	$2,256	$1,535	$2,072
Pot 1				
Min	$254	$240	$306	$240
Max	$2,528	$1,129	$2,538	$2,538
Stdev	$752	$211	$680	$644
2				
Min	$277	$289	$341	$289
Max	$3,290	$1,420	$3,280	$3,290
Stdev	$1,000	$272	$902	$851
3				
Min	$301	$318	$375	$339
Max	$4,051	$1,710	$4,021	$4,051
Stdev	$1,248	$334	$1,124	$1,058
Fillet trawl 1				
Min	$399	.	.	$399
Max	$1,423	.	.	$1,423
Stdev	$258	.	.	$258
2				
Min	$435	.	.	$435
Max	$1,608	.	.	$1,608
Stdev	$304	.	.	$304
3				
Min	$470	.	.	$470
Max	$1,794	.	.	$1,794
Stdev	$351	.	.	$351
H & G trawl 1				
Min	$236	.	.	$236
Max	$2,244	.	.	$2,244
Stdev	$438	.	.	$438
2				
Min	$256	.	.	$256
Max	$2,875	.	.	$2,875
Stdev	$557	.	.	$557
3				
Min	$275	.	.	$275
Max	$3,505	.	.	$3,505
Stdev	$678	.	.	$678
All trawl 1				
Min	$262	.	.	$262
Max	$2,244	.	.	$2,244
Stdev	$392	.	.	$392
2				
Min	$284	.	.	$284
Max	$2,875	.	.	$2,875
Stdev	$498	.	.	$498
3				
Min	$305	.	.	$305
Max	$3,505	.	.	$3,505
Stdev	$606	.	.	$606

Table A47 Three sets of estimates of annual overhead costs per metric ton of cod catch by type of operation and season, 1991-92.

Allocation based on weeks fished

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1	$78	$97	$98	$90
2	$110	$136	$138	$127
3	$150	$186	$189	$174
Pot 1	.	$61	$67	$64
2	.	$81	$90	$86
3	.	$101	$112	$107
Fillet trawl 1	$145	.	.	$145
2	$193	.	.	$193
3	$241	.	.	$241
H & G trawl 1	$90	.	.	$90
2	$121	.	.	$121
3	$151	.	.	$151
All trawl 1	$120	.	.	$120
2	$160	.	.	$160
3	$200	.	.	$200
1992				
Longline 1	$76	$101	$127	$89
2	$108	$143	$180	$125
3	$147	$194	$245	$170
Pot 1	$79	$110	$233	$109
2	$105	$146	$310	$146
3	$132	$183	$388	$182
Fillet trawl 1	$135	.	.	$135
2	$180	.	.	$180
3	$225	.	.	$225
H & G trawl 1	$87	.	.	$87
2	$116	.	.	$116
3	$146	.	.	$146
All trawl 1	$120	.	.	$120
2	$160	.	.	$160
3	$200	.	.	$200
1991-92 average				
Longline 1	$77	$99	$103	$89
2	$108	$140	$146	$126
3	$148	$191	$199	$172
Pot 1	$79	$97	$95	$94
2	$105	$130	$127	$126
3	$132	$162	$159	$157
Fillet trawl 1	$140	.	.	$140
2	$187	.	.	$187
3	$233	.	.	$233
H & G trawl 1	$89	.	.	$89
2	$119	.	.	$119
3	$149	.	.	$149
All trawl 1	$120	.	.	$120
2	$160	.	.	$160
3	$200	.	.	$200

Table A47 Continued.

Allocation based on product weight

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1	$89	$86	$72	$82
2	$98	$95	$80	$91
3	$238	$231	$193	$220
Pot 1	.	$49	$67	$58
2	.	$65	$89	$78
3	.	$82	$111	$97
Fillet trawl 1	$68	.	.	$68
2	$90	.	.	$90
3	$113	.	.	$113
H & G trawl 1	$48	.	.	$48
2	$64	.	.	$64
3	$79	.	.	$79
All trawl 1	$58	.	.	$58
2	$78	.	.	$78
3	$97	.	.	$97
1992				
Longline 1	$80	$76	$73	$78
2	$88	$83	$81	$85
3	$212	$202	$195	$207
Pot 1	$61	$63	$74	$63
2	$81	$84	$98	$84
3	$101	$106	$123	$106
Fillet trawl 1	$71	.	.	$71
2	$94	.	.	$94
3	$118	.	.	$118
H & G trawl 1	$44	.	.	$44
2	$59	.	.	$59
3	$74	.	.	$74
All trawl 1	$62	.	.	$62
2	$83	.	.	$83
3	$104	.	.	$104
1991-92 average				
Longline 1	$83	$79	$73	$80
2	$91	$87	$80	$88
3	$221	$212	$194	$213
Pot 1	$61	$60	$68	$62
2	$81	$80	$91	$82
3	$101	$100	$113	$103
Fillet trawl 1	$69	.	.	$69
2	$92	.	.	$92
3	$115	.	.	$115
H & G trawl 1	$46	.	.	$46
2	$62	.	.	$62
3	$77	.	.	$77
All trawl 1	$60	.	.	$60
2	$80	.	.	$80
3	$100	.	.	$100

Table A47 Continued.

Allocation based on product value

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1	$63	$53	$53	$57
2	$81	$68	$69	$73
3	$159	$134	$135	$144
Pot 1	.	$35	$51	$43
2	.	$46	$68	$57
3	.	$58	$85	$72
Fillet trawl 1	$81	.	.	$81
2	$108	.	.	$108
3	$135	.	.	$135
H & G trawl 1	$61	.	.	$61
2	$81	.	.	$81
3	$102	.	.	$102
All trawl 1	$72	.	.	$72
2	$96	.	.	$96
3	$120	.	.	$120
1992				
Longline 1	$57	$52	$57	$55
2	$74	$67	$74	$71
3	$145	$132	$145	$140
Pot 1	$44	$43	$55	$44
2	$58	$58	$74	$59
3	$73	$72	$92	$74
Fillet trawl 1	$76	.	.	$76
2	$101	.	.	$101
3	$127	.	.	$127
H & G trawl 1	$51	.	.	$51
2	$68	.	.	$68
3	$86	.	.	$86
All trawl 1	$68	.	.	$68
2	$91	.	.	$91
3	$114	.	.	$114
1991-92 average				
Longline 1	$59	$52	$54	$56
2	$76	$67	$70	$72
3	$150	$133	$137	$142
Pot 1	$44	$41	$52	$44
2	$58	$55	$69	$58
3	$73	$69	$86	$73
Fillet trawl 1	$79	.	.	$79
2	$105	.	.	$105
3	$131	.	.	$131
H & G trawl 1	$58	.	.	$58
2	$77	.	.	$77
3	$96	.	.	$96
All trawl 1	$70	.	.	$70
2	$94	.	.	$94
3	$117	.	.	$117

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A48 Estimates of halibut byctch cost per metric ton of cod catch by fishery and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
Higher estimate				
1991				
Longline	$5.18	$16.25	$15.82	$12.07
Pot	.	$.98	$.28	$.63
Trawl	$42.06	.	.	$42.06
1992				
Longline	$9.89	$38.53	$25.07	$21.57
Pot	$.68	$.49	$.75	$.55
Trawl	$49.50	.	.	$49.50
1991-92 average				
Longline	$8.32	$30.44	$17.49	$17.43
Pot	$.68	$.61	$.36	$.58
Trawl	$44.59	.	.	$44.59
Lower estimate				
1991				
Longline	$4.75	$14.90	$14.51	$11.07
Pot	.	$.93	$.27	$.60
Trawl	$24.88	.	.	$24.88
1992				
Longline	$9.07	$35.33	$22.99	$19.78
Pot	$.65	$.46	$.72	$.53
Trawl	$29.29	.	.	$29.29
1991-92 average				
Longline	$7.63	$27.91	$16.04	$15.98
Pot	$.65	$.58	$.34	$.55
Trawl	$26.38	.	.	$26.38

Note: The higher estimates include both the automatic and immediate adjustment in the halibut fishery quotas and more speculative and less immediate adjustments. The lower estimates exclude the latter adjustment.

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A49 Variability of halibut bycatch cost per metric ton of cod catch by fishery and season for higher estimate of halibut bycatch cost per metric ton of halibut bycatch mortality, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline				
Min	$1.69	$4.07	$5.17	$3.56
Max	$59.72	$145.72	$127.51	$127.63
Stdev	$15.56	$26.91	$30.19	$26.81
Pot				
Min	.	$.03	$.07	$.06
Max	.	$3.55	$1.28	$2.57
Stdev	.	$1.32	$.37	$.85
Trawl				
Min	$.00	.	.	$.00
Max	$449.00	.	.	$449.00
Stdev	$58.04	.	.	$58.04
1992				
Longline				
Min	$.55	$9.97	$4.38	$5.11
Max	$133.25	$111.66	$182.46	$98.79
Stdev	$24.77	$24.98	$30.23	$19.65
Pot				
Min	$.00	$.07	$.09	$.05
Max	$1.42	$1.27	$4.58	$1.39
Stdev	$.43	$.44	$1.30	$.40
Trawl				
Min	$.00	.	.	$.00
Max	$216.94	.	.	$216.94
Stdev	$44.81	.	.	$44.81
1991-92 average				
Longline				
Min	$.55	$8.90	$6.33	$4.53
Max	$133.25	$98.79	$182.46	$98.79
Stdev	$21.82	$21.83	$32.58	$20.45
Pot				
Min	$.00	$.07	$.09	$.05
Max	$1.42	$3.55	$4.58	$1.66
Stdev	$.43	$.78	$1.12	$.41
Trawl				
Min	$.00	.	.	$.00
Max	$259.07	.	.	$259.07
Stdev	$39.29	.	.	$39.29

Table A50 Estimates of herring, crab, and salmon bycatch cost per metric ton of cod catch by fishery and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
Herring				
1991				
Longline	$.00	$.00	$.00	$.00
Pot	.	$.00	$.00	$.00
Trawl	$.01	.	.	$.01
1992				
Longline	$.00	$.00	$.00	$.00
Pot	$.00	$.00	$.00	$.00
Trawl	$.09	.	.	$.09
1991-92 average				
Longline	$.00	$.00	$.00	$.00
Pot	$.00	$.00	$.00	$.00
Trawl	$.03	.	.	$.03
Tanner crab				
1991				
Longline	$.03	$.02	$.03	$.03
Pot	.	$.44	$2.35	$1.39
Trawl	$2.57	.	.	$2.57
1992				
Longline	$.03	$.04	$.15	$.05
Pot	$1.23	$1.36	$1.26	$1.32
Trawl	$1.57	.	.	$1.57
1991-92 average				
Longline	$.03	$.04	$.05	$.04
Pot	$1.23	$1.14	$2.17	$1.34
Trawl	$2.23	.	.	$2.23
Red king crab				
1991				
Longline	$.00	$.01	$.01	$.00
Pot	.	$.51	$2.43	$1.47
Trawl	$.31	.	.	$.31
1992				
Longline	$.01	$.22	$.03	$.09
Pot	$.05	$.19	$.12	$.14
Trawl	$.11	.	.	$.11
1991-92 average				
Longline	$.01	$.14	$.01	$.05
Pot	$.05	$.27	$2.05	$.55
Trawl	$.24	.	.	$.24

Note: Tanner crab refers only to C. bairdi.

Table A50 Continued.

	Jan-May	Jun-Aug	Sep-Dec	Annual
Chinook salmon				
1991				
Longline	$.02	$.03	$.00	$.02
Pot	.	$.00	$.00	$.00
Trawl	$1.98	.	.	$1.98
1992				
Longline	$.02	$.00	$.00	$.01
Pot	$.00	$.00	$.00	$.00
Trawl	$2.45	.	.	$2.45
1991-92 average				
Longline	$.02	$.01	$.00	$.01
Pot	$.00	$.00	$.00	$.00
Trawl	$2.14	.	.	$2.14
Herring, crab, and salmon				
1991				
Longline	$.05	$.05	$.04	$.05
Pot	.	$.96	$4.77	$2.86
Trawl	$4.86	.	.	$4.86
1992				
Longline	$.06	$.27	$.17	$.15
Pot	$1.28	$1.55	$1.38	$1.47
Trawl	$4.22	.	.	$4.22
1991-92 average				
Longline	$.06	$.19	$.07	$.10
Pot	$1.28	$1.40	$4.22	$1.89
Trawl	$4.64	.	.	$4.64

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A51 Estimates of groundfish bycatch cost per metric ton of cod catch by fishery and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline	$10.77	$40.41	$20.94	$22.65
Pot	.	$.77	$.83	$.80
Trawl	$140.37	.	.	$140.37
1992				
Longline	$11.42	$20.94	$27.30	$15.96
Pot	$.80	$3.52	$3.52	$2.75
Trawl	$135.69	.	.	$135.69
1991-92 average				
Longline	$11.21	$28.01	$22.09	$18.87
Pot	$.80	$2.84	$1.26	$2.15
Trawl	$138.77	.	.	$138.77

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A51.1 Groundfish bycatch and bycatch cost by species and gear in the BSAI cod fishery, 1991-92.

	Bycatch (mt)	Bycatch cost per mt of bycatch	Bycatch cost (thousands)	Bycatch cost per mt of cod
Longline				
1991				
Arrowtooth	1,999	$21	$43	$1
Atka mack	3	$343	$1	$0
Flat other	262	$84	$22	$0
Pollock	2,386	$220	$525	$7
Rock sole	18	$279	$5	$0
Rockfish	245	$249	$61	$1
Sablefish	455	$1,402	$637	$9
Turbot	553	$566	$313	$4
Yellowfin	3	$220	$1	$0
Other	6,683	$13	$88	$1
Total	12,606	$340	$1,695	$23
1992				
Arrowtooth	1,620	$4	$7	$0
Atka mack	46	$326	$15	$0
Flat other	265	$65	$17	$0
Pollock	3,104	$229	$712	$7
Rock sole	27	$256	$7	$0
Rockfish	807	$257	$207	$2
Sablefish	225	$1,352	$305	$3
Turbot	644	$230	$148	$2
Yellowfin	86	$206	$18	$0
Other	10,706	$11	$114	$1
Total	17,531	$294	$1,550	$16
Pot				
1991				
Arrowtooth	1	$21	$0	$0
Atka mack	1	$343	$0	$0
Flat other	1	$84	$0	$0
Pollock	1	$220	$0	$0
Rock sole	0	$279	$0	$0
Rockfish	1	$249	$0	$0
Sablefish	0	$1,402	$0	$0
Turbot	0	$566	$0	$0
Yellowfin	2	$220	$1	$0
Other	181	$13	$2	$0
Total	189	$340	$4	$1

Table A51.1 (Continued).

	Bycatch (mt)	Bycatch cost per mt of bycatch	Bycatch cost (thousands)	Bycatch cost per mt of cod
1992				
Arrowtooth	3	$4	$0	$0
Atka mack	9	$326	$3	$0
Flat other	0	$65	$0	$0
Pollock	6	$229	$1	$0
Rock sole	2	$256	$1	$0
Rockfish	3	$257	$1	$0
Sablefish	13	$1,352	$18	$1
Turbot	5	$230	$1	$0
Yellowfin	12	$206	$2	$0
Other	543	$11	$6	$0
Total	596	$294	$32	$3
Trawl				
1991				
Arrowtooth	3,297	$21	$70	$1
Atka mack	840	$343	$288	$4
Flat other	4,221	$84	$353	$4
Pollock	36,169	$220	$7,958	$98
Rock sole	5,961	$279	$1,662	$21
Rockfish	2,953	$249	$735	$9
Sablefish	18	$1,402	$25	$0
Turbot	204	$566	$115	$1
Yellowfin	662	$220	$146	$2
Other	4,258	$13	$56	$1
Total	58,583	$340	$11,408	$141
1992				
Arrowtooth	2,634	$4	$12	$0
Atka mack	3,175	$326	$1,036	$25
Flat other	2,284	$65	$148	$4
Pollock	13,718	$229	$3,144	$76
Rock sole	3,226	$256	$825	$20
Rockfish	1,244	$257	$319	$8
Sablefish	9	$1,352	$12	$0
Turbot	78	$230	$18	$0
Yellowfin	494	$206	$102	$2
Other	2,670	$11	$29	$1
Total	29,533	$294	$5,645	$136

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A52 Variability of groundfish bycatch cost estimates per metric ton of cod catch by type of operation and season, 1991-92.

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline				
Min	$.37	$1.52	$1.80	$1.66
Max	$478.61	$1,038.18	$394.84	$745.20
Stdev	$98.88	$266.23	$67.48	$188.44
Pot				
Min	.	$.44	$.08	$.08
Max	.	$5.25	$2.48	$4.57
Stdev	.	$1.66	$.78	$1.31
Trawl				
Min	$14.33	.	.	$14.33
Max	$1,014.02	.	.	$1,014.02
Stdev	$161.11	.	.	$161.11
1992				
Longline				
Min	$.26	$.78	$.05	$.26
Max	$968.49	$1,067.30	$873.45	$994.51
Stdev	$143.24	$209.17	$182.96	$202.08
Pot				
Min	$.03	$.17	$.24	$.03
Max	$29.56	$42.89	$21.80	$29.56
Stdev	$7.76	$8.90	$6.25	$7.04
Trawl				
Min	$8.88	.	.	$8.88
Max	$7,487.45	.	.	$7,487.45
Stdev	$1,119.49	.	.	$1,119.49
1991-92 average				
Longline				
Min	$.26	$2.27	$.75	$.26
Max	$769.56	$971.52	$873.45	$873.45
Stdev	$127.71	$227.26	$160.86	$199.66
Pot				
Min	$.03	$.28	$.08	$.11
Max	$29.56	$29.58	$4.77	$29.56
Stdev	$7.76	$5.91	$1.13	$6.16
Trawl				
Min	$8.88	.	.	$8.88
Max	$750.66	.	.	$750.66
Stdev	$149.88	.	.	$149.88

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Table A53 Variability of net benefit per metric ton of cod catch (ANB) by trimester and fishery for three different estimates of average variable cost and two different estimates of average prohibited species bycatch cost, 1991-92.

ANB using higher estimates of prohibited species bycatch cost

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1				
Min	$165	$13	-$379	-$379
Max	$1,279	$2,473	$775	$1,990
Stdev	$211	$573	$222	$445
2				
Min	$132	-$64	-$458	-$458
Max	$1,246	$2,396	$696	$1,913
Stdev	$211	$573	$222	$444
3				
Min	$95	-$78	-$472	-$472
Max	$1,209	$2,382	$682	$1,898
Stdev	$211	$573	$222	$444
Pot 1				
Min	.	$150	$158	$171
Max	.	$1,408	$981	$1,408
Stdev	.	$551	$273	$426
2				
Min	.	$109	$112	$126
Max	.	$1,366	$935	$1,366
Stdev	.	$551	$273	$426
3				
Min	.	$67	$65	$80
Max	.	$1,325	$889	$1,325
Stdev	.	$551	$273	$427
All trawl 1				
Min	-$723	.	.	-$723
Max	$1,238	.	.	$1,238
Stdev	$409	.	.	$409
2				
Min	-$794	.	.	-$794
Max	$1,167	.	.	$1,167
Stdev	$409	.	.	$409
3				
Min	-$865	.	.	-$865
Max	$1,096	.	.	$1,096
Stdev	$409	.	.	$409
1992				
Longline 1				
Min	$22	-$97	-$207	$21
Max	$3,788	$1,845	$1,170	$3,045
Stdev	$557	$401	$241	$463
2				
Min	-$16	-$182	-$327	-$48
Max	$3,750	$1,759	$1,050	$2,991
Stdev	$557	$401	$241	$463
3				
Min	-$48	-$193	-$329	-$67
Max	$3,718	$1,748	$1,047	$2,967
Stdev	$557	$401	$241	$463

Table A53 (Continued).

	Jan-May	Jun-Aug	Sep-Dec	Annual
Pot 1				
Min	$143	-$183	-$108	-$183
Max	$2,030	$1,293	$188	$1,949
Stdev	$540	$345	$81	$424
2				
Min	$89	-$258	-$268	-$258
Max	$1,976	$1,218	$29	$1,893
Stdev	$540	$345	$81	$432
3				
Min	$35	-$334	-$427	-$334
Max	$1,922	$1,143	-$130	$1,836
Stdev	$540	$345	$81	$442
All trawl 1				
Min	-$7,045	.	.	-$7,045
Max	$2,122	.	.	$2,122
Stdev	$1,234	.	.	$1,234
2				
Min	-$7,113	.	.	-$7,113
Max	$2,055	.	.	$2,055
Stdev	$1,234	.	.	$1,234
3				
Min	-$7,180	.	.	-$7,180
Max	$1,987	.	.	$1,987
Stdev	$1,234	.	.	$1,234
1991-92 average				
Longline 1				
Min	$22	$5	-$225	$2
Max	$3,077	$2,300	$1,170	$2,324
Stdev	$462	$483	$225	$406
2				
Min	-$16	-$76	-$307	-$67
Max	$3,040	$2,222	$1,050	$2,259
Stdev	$462	$483	$228	$403
3				
Min	-$48	-$88	-$320	-$85
Max	$3,007	$2,208	$1,047	$2,239
Stdev	$462	$483	$227	$404
Pot 1				
Min	$143	-$183	-$108	-$183
Max	$2,030	$1,377	$981	$1,825
Stdev	$540	$368	$325	$399
2				
Min	$89	-$258	-$268	-$258
Max	$1,976	$1,326	$935	$1,772
Stdev	$540	$372	$372	$409
3				
Min	$35	-$334	-$427	-$334
Max	$1,922	$1,276	$889	$1,719
Stdev	$540	$377	$422	$419

Table A53 (Continued).

	Jan-May	Jun-Aug	Sep-Dec	Annual
All trawl 1				
Min	-$925	.	.	-$925
Max	$2,122	.	.	$2,122
Stdev	$447	.	.	$447
2				
Min	-$995	.	.	-$995
Max	$2,055	.	.	$2,055
Stdev	$447	.	.	$447
3				
Min	-$1,066	.	.	-$1,066
Max	$1,987	.	.	$1,987
Stdev	$447	.	.	$447

ANB using lower estimates of prohibited species bycatch cost

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline 1				
Min	$166	$14	-$372	-$372
Max	$1,284	$2,476	$784	$1,995
Stdev	$211	$574	$222	$446
2				
Min	$133	-$63	-$451	-$451
Max	$1,251	$2,399	$705	$1,917
Stdev	$211	$574	$222	$445
3				
Min	$95	-$77	-$465	-$465
Max	$1,214	$2,384	$691	$1,903
Stdev	$211	$574	$222	$445
Pot 1				
Min	.	$150	$158	$172
Max	.	$1,410	$991	$1,410
Stdev	.	$551	$274	$425
2				
Min	.	$109	$112	$126
Max	.	$1,368	$944	$1,368
Stdev	.	$551	$274	$425
3				
Min	.	$67	$66	$81
Max	.	$1,327	$898	$1,327
Stdev	.	$551	$274	$426
All trawl 1				
Min	-$660	.	.	-$660
Max	$1,259	.	.	$1,259
Stdev	$411	.	.	$411
2				
Min	-$731	.	.	-$731
Max	$1,188	.	.	$1,188
Stdev	$411	.	.	$411
3				
Min	-$802	.	.	-$802
Max	$1,117	.	.	$1,117
Stdev	$411	.	.	$411

Table A53 (Continued).

	Jan-May	Jun-Aug	Sep-Dec	Annual
1992				
Longline 1				
Min	$23	-$89	-$206	$25
Max	$3,794	$1,847	$1,175	$3,051
Stdev	$558	$401	$241	$464
2				
Min	-$15	-$175	-$326	-$45
Max	$3,756	$1,761	$1,055	$2,997
Stdev	$558	$401	$241	$464
3				
Min	-$47	-$186	-$329	-$63
Max	$3,725	$1,750	$1,052	$2,973
Stdev	$558	$401	$241	$464
Pot 1				
Min	$143	-$183	-$108	-$183
Max	$2,030	$1,295	$190	$1,950
Stdev	$539	$343	$81	$423
2				
Min	$89	-$258	-$268	-$258
Max	$1,976	$1,220	$31	$1,893
Stdev	$539	$343	$81	$431
3				
Min	$35	-$333	-$427	-$333
Max	$1,922	$1,145	-$128	$1,837
Stdev	$539	$343	$81	$441
All trawl 1				
Min	-$7,045	.	.	-$7,045
Max	$2,145	.	.	$2,145
Stdev	$1,240	.	.	$1,240
2				
Min	-$7,113	.	.	-$7,113
Max	$2,078	.	.	$2,078
Stdev	$1,240	.	.	$1,240
3				
Min	-$7,180	.	.	-$7,180
Max	$2,010	.	.	$2,010
Stdev	$1,240	.	.	$1,240
1991-92 average				
Longline 1				
Min	$23	$10	-$225	$4
Max	$3,082	$2,302	$1,175	$2,329
Stdev	$463	$483	$226	$407
2				
Min	-$15	-$71	-$306	-$65
Max	$3,045	$2,224	$1,055	$2,264
Stdev	$463	$483	$228	$404
3				
Min	-$47	-$84	-$319	-$84
Max	$3,012	$2,211	$1,052	$2,244
Stdev	$463	$483	$228	$405

Table A53 (Continued).

	Jan-May	Jun-Aug	Sep-Dec	Annual
Pot 1				
Min	$143	-$183	-$108	-$183
Max	$2,030	$1,379	$991	$1,826
Stdev	$539	$366	$328	$399
2				
Min	$89	-$258	-$268	-$258
Max	$1,976	$1,328	$944	$1,773
Stdev	$539	$371	$376	$408
3				
Min	$35	-$333	-$427	-$333
Max	$1,922	$1,278	$898	$1,720
Stdev	$539	$375	$425	$418
All trawl 1				
Min	-$864	.	.	-$864
Max	$2,145	.	.	$2,145
Stdev	$448	.	.	$448
2				
Min	-$934	.	.	-$934
Max	$2,078	.	.	$2,078
Stdev	$448	.	.	$448
3				
Min	-$1,005	.	.	-$1,005
Max	$2,010	.	.	$2,010
Stdev	$448	.	.	$448

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

APPENDIX B

SCIENTIFIC STUDIES SUPPORTING BYCATCH SURVIVAL ESTIMATES

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This appendix summarizes scientific studies supporting bycatch survival estimates.

Halibut

Survival from trawl catches

Halibut discard survival rates from trawl catches were established from a tagging experiment performed by the International Pacific Halibut Commission (Hoag 1975). The physical condition of over 2,000 halibut caught and released by domestic B.C. trawlers was categorized into five levels based on their external injuries and physical activities. Condition was positively correlated with length of fish and negatively correlated with time on deck and the weight of the total catch. Most of the halibut were tagged and the recovery rate declined with poorer condition.

The survival of fish was estimated from the recovery rate of tags from 1970-73 (longline and trawl fisheries) and the expected rates of fishing mortality and other losses. The average survival of halibut in all conditions was 28 percent for those less than 80 cm to 55 percent for those greater than 80 cm. By condition factor and size, survival was estimated as follows:

Length	Excellent	Good	Fair	Poor	Dead
<80 cm	48%	52%	28%	26%	3%
>80 cm	92%	74%	50%	43%	18%

These data were re-examined by Clark et al. (1992) who determined that the reporting rate used for small fish in the survival calculations was almost surely underestimated since smaller fish were subject to higher trawl mortality rates and therefore lower reporting rates. This results in better estimated survival for small fish, which, by condition category, is not much different than survival for large fish. Accordingly, size was disregarded in estimating trawl bycatch survival and the following survival rates were adopted: excellent 80%, poor 45%, and dead 10%.

Supporting information is available from the hundreds of thousands of halibut annually examined for viability in Bering Sea and Gulf of Alaska trawl fisheries. Williams and Wilderbuer (1992) applied the trawl survival rates to this data to estimate halibut discard survival by directed fishery.

Survival from longline catches

Experiments to determine survival of longline caught halibut comparable to Hoag's (1975) study have not been conducted. However, data from other IPHC studies suggest that (1) handling mortality of longline caught halibut in "excellent" condition ranges from 2 to 5% (Peltonen 1969), and (2) survival of "poor" condition fish is approximately half that of fish in "excellent" condition (Myhre 1974). Williams and Wilderbuer (1992) applied these rates (with the additional assumption that fish classified as dead actually died) to the observer collected halibut viability information to calculate discard mortality rates for the 1990 and 1991 Gulf of Alaska and Bering Sea/Aleutian Islands longline fisheries.

Survival from pots

There is no information on the survival of pot caught halibut. A study by Williams et al. (1982) to determine the difference in catch rates from pots with or without tanner boards indicated that nearly all halibut suffered from minor abrasions caused by either struggling in the pot or by being in contact with crab. It is known from NMFS sablefish pot surveys that extended soak time in some areas will cause mortality from amphipods (sand fleas). Halibut mortality in pots from ADF&G crab surveys (1974-84) ranged from 4-35% (Williams et al. 1989). Observer collected viability information indicates that 97% and 95% of the halibut examined were in excellent condition in pot fisheries in the Bering Sea and the Gulf of Alaska, respectively (Williams and Wilderbuer 1992).

Crab

Survival from trawl catches

King and Tanner crab survival from bottom trawling was examined in a trawl comparison study in 1987. In an industry-NMFS sponsored project (Stevens 1990 and Natural Resource Consultants 1988), 717 trawl caught crab were examined for viability and then placed in tanks of flowing seawater for 48 hours to determine survivability. Overall survival was 21% for king crabs and 22% for Tanner crabs. All trawl caught crab are considered dead in the calculations of Prohibited Species Catch by the North Pacific Fisheries Management Council. Observer collected viability observations from the 1990 Bering Sea fishery ranged from 28-52% "excellent" for king crab and 6-30% for Tanner crab (Guttormsen et al. 1992).

Survival from pots

No studies have been performed to directly calculate mortality from pot catches. An ADF&G study by Dr. Shirley (unpublished Sea Grant study, 1990) examined the effects of handling on the survival of sublegal Dungeness crabs. A laboratory experiment which mimicked the catching procedure, pot lifting, air exposure and release from a commercial vessel resulted in up to 90% mortality for crab caught 3 times a month for 2 months and 10% mortality for the control group (no handling). In addition, Carls and O'Clair (1989) examined the effects of exposure to cold air (typical of temperatures during the Bering Sea winter) on king and Tanner crab and found effects including mortality and reduced vigor, growth, feeding and limb autotomy.

All 997 red king crab examined for condition by observers in the 1990 pot fishery were classified as "excellent". Tanner crab observations for the same year ranged from 96-98% "excellent".

Salmon and Herring

No studies have been completed to directly determine the survival of salmon and herring from demersal trawls, probably since they are usually dead with a substantial loss of scales. High seas tagging studies with purse seines and longlines have experienced catch and handling mortality using gear much less abrasive to salmon than bottom trawls (Meyers and Rogers 1983). A University of Washington study in 1956 (Hartt 1962) examined mortality from scale loss and concluded that moderate scale loss (small patches of scales, less than 25% of the body) may not be a serious problem but large scale loss inhibited the immune system. All salmon and herring bycatch are considered dead in the calculation of Prohibited Species Catch by the North Pacific Fisheries Management Council. No viability observations are recorded by the observer program.

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APPENDIX C

DISCARD MORTALITY RATE ESTIMATES USED IN THIS REPORT

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This appendix presents the method of estimation for the discard mortality rates estimates used in this report.

Williams and Wilderbuer (1992) estimated halibut discard mortality rates for various 1991 groundfish fisheries. They used condition factor information from the Observer Program and the survival rates by conditions factor category presented in the previous appendix. The resulting halibut discard mortality rate estimates for BSAI groundfish fisheries are listed below.

Pot	5%
Longline	20%
Trawl	
Mid-water pollock	80%
Atka mackerel, rock sole, yellowfin sole, and other flatfish	70%
Cod, rockfish, and bottom pollock	60%
Sablefish, turbot, and arrowtooth flounder	40%

Based on the results of a trawl comparison study in 1987 (Stevens 1990 and Natural Resource Consultants 1988), it is assumed that the discard mortality rate for king crab and Tanner crab is 80% in the trawl fisheries. Because the literature provides no comparable estimates for the longline and pot fisheries, these mortality rates had to be estimated. This was done by independently estimating crab discard mortality rates in the trawl, longline, and pot fisheries and then adjusting all the estimates proportionally so that the adjusted rate for the trawl fishery equaled 80%. The independent estimates were based on condition factor information from the Observer Program for 1990 (Guttormsen et al. 1992) and the following survival rates for the three conditions factors: excellent 80%, poor 45%, and dead 10%. These are the survival rates for halibut in the trawl fishery. The percent of crab for each condition factor category and gear was as follows:

Trawl red king crab	52.4%, 27.5%, and 20.1%;
Pot red king crab	100%, 0%, and 0%;
Longline red king crab	no estimates are available;
Trawl bairdi	30.5%, 32.0%, and 37.5%;
Pot bairdi	97.3%, 1.4%, and 1.3%;
Longline bairdi	71.2%, 21.7%, and 7.2%.

The resulting adjusted discard mortality rates which are used in this report are as follows:

Trawl red king crab	80%
Pot red king crab	37%
Longline red king crab	37%
Trawl bairdi	80%
Pot bairdi	30%
Longline bairdi	45%.

For each groundfish fishery, the discard mortality rate is assumed to be 100% for salmon, herring, and groundfish. The importance of the accuracy of each of these estimates is naturally dependent on the level of bycatch in each of the three cod fisheries. At the extreme, if there is almost no bycatch of a particular species in one of the cod fisheries, the accuracy of the estimate for that species and fishery is of no importance.

Unless otherwise stated, these discard mortality rates are used to calculate bycatch mortality and bycatch mortality rates for 1990-1992.

APPENDIX D

METHODS USED TO ESTIMATE NET BENEFIT PER METRIC TON OF COD CATCH BY BSAI PACIFIC COD FISHERY AND TRIMESTER FOR 1991 AND 1992

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Estimates of net benefits per metric ton of cod catch were generated for each of three cod fisheries by trimester and year for 1991 and 1992. This was done using estimates of average gross revenue (AGR), average harvesting and processing cost (AHPC), and the average opportunity cost of bycatch (AOCB). The method used to estimate each of these three determinants of average net benefit (ANB) is presented following a brief description of which catch, bycatch, and product weight data were used.

The current definitions of target fisheries were used to identify the data associated with each of the three cod fisheries. Observations are defined in terms of a processor, week, area, and gear. If the estimate of retained cod catch is greater than that of any other potential target species for an observation, the data for that observation are by definition associated with the cod fishery of that specific gear.

ESTIMATING GROSS REVENUE PER METRIC TON OF COD CATCH (AGR)

Blend estimates of total cod catch, Weekly Processor Report estimates of product weights by species and product form, and estimates of FOB Alaska prices were used to estimate gross revenue per metric ton of cod catch (AGR) for each cod fishery, trimester, and year. These estimates include the value of all groundfish products associated with the cod fisheries. Estimates of AGR by processor also were generated. The estimates by processor are used to determine the variability in the estimates due to inter-processor differences in the species composition of catch, discard rates, product recovery rates, monthly distribution of catch, and product mix with respect to product forms and species. This variability provides a partial measure of the uncertainty associated with the 1991 and 1992 estimates of AGR for each of the three cod fisheries. It also provides a means of determining the extent to which the estimates overlap for individual operations in different fisheries.

With the exception of H&G cod, annual prices were used to estimate the FOB Alaska value of catch in the three cod fisheries. For H&G cod, base annual prices were adjusted seasonally. The seasonal adjusters were: 0.90 for January-April, 0.75 for May-August, 0.85 for September-October, and 1.0 for November-December. The base annual prices for H&G eastern cut were $0.86 per pound for the longline and pot fisheries and $0.73 per pound for the trawl fishery. The prices for other cod H&G products were set based on the eastern cut prices listed above and the percentage differences between eastern cut and other H&G prices from the 1991 ADF&G/CFEC/NMFS annual groundfish processor survey. For each season, the price equals the product of the base price and the seasonal adjuster. The same FOB Alaska prices were used for 1991 and 1992. The ADF&G/CFEC/NMFS annual groundfish processor survey for 1991 is the source of all the price estimates except those for H&G cod and both cod and pollock fillets. The H&G prices are based on Ishinomaki Auction prices in Japan for trawl and longline H&G medium size cod for January 1991 - July 1992 (Appendix A, Table A35). The pollock and fillet prices are based on weekly prices reported in Urner Barry Seafood Price Current for 8-16 oz cod fillets and 2-4 oz pollock fillets for the same period (Appendix A, Table A34). The average cod and pollock fillet prices for that period were $2.64 and $1.61 per pound, respectively. The FOB Seattle fillet prices were converted to FOB Alaska prices by subtracting $0.10 per pound. That is approximately the cost of freight and insurance from Dutch Harbor to Seattle and warehousing costs for one month. The Japanese auction prices were converted to FOB Alaska prices by converting the Yen per kg prices to Dollar per lb prices and subtracting the additional costs associated with selling at the auction.

Estimates of 1991 and 1992 total catch and retained catch by species are presented in Table D1 for each of the three cod fisheries. The estimates of product weights, prices, and product values by year, fishery, species, and product form are included in Table D2. That table also includes prices by trimester for cod H&G products because seasonal price adjustments were made only for these products. Blend estimates of total cod catch, estimates of total product weight per metric ton of cod catch, estimates of total product value, and the resulting estimates of AGR by year, trimester, and fishery are presented in Table D3.

ESTIMATING HARVESTING AND PROCESSING COST PER METRIC TON OF COD CATCH (AHPC)

The inputs that are used to harvest and process fish in each of the three cod fisheries are of value to society because they can be used to produce the products of that cod fishery or other goods and services. Therefore, the opportunity cost of using these inputs is the basis of their value. For inputs that are purchased on an ongoing basis, the prices paid for the inputs are used as estimates of their per unit opportunity costs. This includes inputs such as fuel, labor, transportation, maintenance, communications, technicians, and packaging material. The amount paid for an input will not always provide an accurate estimate of its opportunity cost; however, better estimates typically are not available. If the market for inputs is relatively competitive, the payments for inputs tend to reflect opportunity costs.

For other inputs that are used but not purchased on an ongoing basis, there are no explicit payments that can be used to estimate their opportunity costs. These inputs include the use of fishing vessels and processing plants and equipment.

The opportunity cost of using a vessel or a processing plant in a cod fishery equals the net value foregone by not using it in its next most productive manner. If there is absolutely no other use for a vessel or plant, the opportunity cost of using it is zero. From society's perspective, the opportunity cost may even be zero if the alternative use is participation in another fishery in which catch is already constrained. The opportunity cost in that case is zero if that alternative use simply replaces effort of a similar vessel that was already participating in the alternative fishery.

Because there is not sufficient information to quantify the opportunity cost of using a vessel or plant in a cod fishery, this component of harvesting and processing costs is not included in the estimates of net benefits. Another cost that is ignored is that associated with replacing vessels and plants that wear out or become obsolete. A discussion of the potential effects of ignoring these two types of costs is included in Section 2.2.13 of the EA/RIR/IRFA.

Variable Costs

Among the inputs that are purchased on an ongoing basis, there are inputs whose use is dependent principally either on time spent (i.e. effort) in the cod fishery or on the amount of fish harvested and processed. The former include fuel and lubricants, regular maintenance, groceries, transportation for the crew, and technicians. The latter include crewshare and wages, packing materials, transportation of supplies and products, product storage, and bait. These will be referred to as variable costs.

Estimates of variable harvesting and processing costs per metric ton of cod catch were generated by year, trimester, and fishery and, in the case of factory trawlers, by principal product form. This was done using three alternative cost models for each of four types of catcher/processor operations. Because, catcher/processors dominate all three cod fisheries, the absence of separate variable cost models for catcher boat-onshore processing operations, is not expected to introduce a substantial bias even if the variable costs differ substantially between catcher/processor and catcher boat-onshore processing operations

Estimates were also generated for each individual catcher/processor. The estimates by processor are used to determine the variability in the estimates due to modeled differences among processors. This variability provides a partial measure of the uncertainty associated with the 1991 and 1992 estimates of variable cost per metric ton of cod catch for each of the three cod fisheries. It also provides a means of determining the extent to which the estimates overlap for individual operations in different fisheries.

The parameter values and the aggregate values of the variables used in the variable cost models are included in Tables D4 and D5, respectively. Each of the three cost models for the factory longliners is based on information for a different vessel. For each of the other types of catcher/processors, all three models are based on information for a single vessel. For these operations, the first and third models are the second model with the time dependent variable cost decreased by 25% and increased by 25%, respectively. The resulting ranges of variable cost estimates are substantially larger for these operations than for the factory longliners.

Overhead Costs

There are other inputs that are purchased on an ongoing to annual basis that are not closely linked to effort or catch and production. The associated costs include those for accounting services, legal fees, administrative/office, marketing, insurance, moorage, and permits. If a harvesting or processing operation is involved with activities other than a single cod fishery, it is difficult to say which of these overhead costs should be charged against a specific cod fishery. Therefore, there are two questions to answer. First, should these overhead costs be included in the estimates of net benefits? Second, if they should be included, how should it be done?

Should overhead costs be considered? The correct answer to this question can be found by determining whether these costs would be considered if the market mechanism were used to allocate cod. The willingness of each operation to pay for the right to harvest cod will indicate what the market solution would be. All else being equal, an operation with the higher overhead costs per metric ton of cod catch will be willing to pay less for the ongoing right to harvest cod. However, there are two exceptions in which the willingness to pay for cod and the market solution would not be affected by these costs.

First, operations that cover all these costs in other fisheries would not consider such costs in determining their willingness to pay for the right to harvest cod. Many of the pot gear operations may be in this category because the cod fishery is to a great extent a supplemental fishery for these operations. However, with open access fisheries, entry into the crab and cod fisheries would tend to decrease the ability of pot operations to cover their overhead costs in the crab fisheries and, therefore, decrease the number of fishing or processing operations subject to this exception.

Second, if the Council's allocation decision will not affect the entry or exit of vessels or processing plants with respect to the fishing industry as a whole, then the Council's actions have no effect on total overhead costs. With either of these two exceptions, overhead costs should be ignored in evaluating the options being considered.

How should annual overhead costs be allocated? There are several equally arbitrary but commonly used methods for allocating the annual overhead costs of a fishing operation that participates in several fisheries. Unfortunately, there is no theoretically correct way to allocate such costs. Three alternative methods are used in this report.

With the first method, the estimate of the overhead cost associated with a cod fishery, for each catcher/processor that participated in that cod fishery, is the product of: (1) an estimate of the overhead cost per week of operation for a "representative catcher/processor" in that cod fishery and (2) the number of weeks each vessel participated in that cod fishery during the year. Information provided by the industry and the weekly blend catch estimates, respectively, are the sources of the former and latter. For each catcher/processor, the number of weeks in a BSAI cod fishery is the number of unique weeks the vessel participated in that cod fishery based on blend estimates of retained catch and the definition of participation in a cod fishery.

With the second method, the corresponding estimate for each catcher/processor is the product of: (1) an estimate of the overhead cost per pound of processed product for a "representative catcher/processor" in that cod fishery and (2) the pounds of processed products of each vessel while participating in that cod fishery. Information provided by the industry and the Weekly Processor Report data, respectively, are the sources of the former and latter.

Finally with the third method, the corresponding estimate for each catcher/processor is the product of: (1) an estimate of the overhead cost per dollar of processed product for a "representative catcher/processor" in that cod fishery and (2) the dollars of processed product of each vessel while participating in that cod fishery.

In methods one through three, the average for each "representative vessel" was its annual overhead costs divided by its annual weeks of operation in all Alaska groundfish fisheries, its annual product weight in all Alaska groundfish fisheries, and its annual product value from all Alaska groundfish fisheries, respectively. For the purposes of the overhead cost models, the "representative vessels" were modeled as if they only participated in Alaska groundfish fisheries.

Estimates of overhead cost per metric ton of cod catch were generated by year, trimester, and fishery and, in the case of factory trawlers, by principal product form. This was done using the three alternative methods for allocating overhead costs and three versions of a "representative vessel" for each type of operation. The parameter values and the aggregate values of the variables used in the overhead cost models are included in Tables D4 and D5, respectively. For the reasons stated in Section 2.2.13 of the EA/RIR/IRFA, overhead costs were not included in the estimates of net benefits.

ESTIMATING THE OPPORTUNITY COST OF GROUNDFISH AND PROHIBITED SPECIES BYCATCH

Estimates of the opportunity cost of groundfish and prohibited species bycatch are used in estimating the net benefits of harvesting cod in each of the three cod fisheries because this bycatch and the resulting bycatch mortality is part of the cost of harvesting cod. The opportunity cost of prohibited species bycatch is based on estimates of the impact cost of bycatch where that cost is calculated as the FOB Alaska value of foregone catch net of variable costs. The basis of each estimate of impact cost per unit of bycatch for the prohibited species is presented in Table D6.

The estimates are based on the assumption that product prices are not affected by the amount of catch that is foregone. If prices increase as a result of the decreased catch, the estimates overstate the net value foregone due to bycatch. For example, if the price of halibut is highly responsive to the decrease in catch (i.e., if the demand is inelastic with respect to the price), the gross value of halibut products would actually increase as the result of decreased halibut catch. In that case, halibut bycatch would result in net benefits to the halibut fishery but not to halibut consumers. Prices are expected to increase as the result of decreased catch but not sufficiently to prevent a decrease in total product value.

Because halibut bycatch usually accounts for most of the prohibited species bycatch impact cost and because the effect of halibut bycatch on future halibut catch has a certain component and a more speculative component, the opportunity cost of halibut bycatch is presented as a range. The lower end of the range is based solely on what has been the immediate and automatic reduction in the halibut fishery quota due to estimated halibut bycatch mortality in the groundfish fisheries. That adjustment has been a 1 mt reduction in the total halibut fishery quota for each 1 mt of estimated halibut bycatch mortality. The upper end of the range for each of the three cod fisheries is set equal to the estimate of yield loss recently developed by IPHC staff. With a discount rate of 7%, the estimates of the discounted halibut fishery yield loss per metric ton of bycatch mortality for the three cod fisheries are: 1.09 mt for longliners, 1.05 mt for pots, and 1.69 mt for trawls (Table D7).

The lower estimates are expected to understate the actual catch foregone in the halibut fishery because they use less information and do not account for subsequent adjustments to halibut fishery quotas. The higher estimates attempt to account for both the immediate and subsequent adjustments to halibut fishery quotas. If the estimates of the subsequent adjustments are better approximations of what the actual adjustments will be than are the estimates that there will be no subsequent adjustments, the higher estimates are clearly better.

For the other prohibited species, the comparable low end of the range would be zero because there is not automatic or immediate adjustment to the crab, herring, or salmon fishery quotas as the result of estimated bycatch mortality in the cod fisheries. That is, for these fisheries, recent or expected bycatch in the groundfish fishery is not taken off the top to set the quotas.

The cost of halibut bycatch mortality in the cod fisheries can be estimated either on the basis of foregone catch and benefits for the halibut fisheries or on the basis of foregone catch and benefits for other groundfish fishery due to the use of part of the halibut PSC limit in the cod fisheries. Previous analyses of halibut bycatch management alternatives considered by the Council have indicated that when the halibut PSC limits reduce groundfish catch, the cost of halibut bycatch in terms of foregone catch and benefits for the groundfish fishery typically is substantially greater than the cost of halibut bycatch in terms of foregone catch and benefits for the halibut fishery. Therefore, determining the correct basis for estimating the cost of halibut bycatch is important.

The correct basis for estimating the cost of halibut bycatch mortality in a cod fishery depends on whether the halibut PSC limits are expected to reduce groundfish catch. If the catch in the groundfish trawl fishery, for example, is expected to be reduced by the halibut PSC limit, the halibut bycatch cost estimate for the cod trawl fishery should be based on forgone catch and benefits for the other groundfish fisheries. However, if catch is not expected to be reduced by the halibut PSC limit, the halibut bycatch cost estimate for the cod fishery should be based on forgone catch and benefits for the halibut fisheries.

The choice of the correct basis for estimating halibut bycatch cost has some interesting implications. For example, if the halibut PSC limits are such that groundfish catch is constrained in the trawl fisheries but not in the longline fisheries, the halibut bycatch cost for the longline fishery should be based on foregone catch and benefits in the halibut fishery but the cost of halibut bycatch in the trawl fishery should be based on foregone catch and benefits for the other groundfish fisheries. If the resulting estimate of the cost per unit of halibut bycatch mortality for the trawl fishery is greater than that for the longline fishery, an increase in the trawl halibut PSC limit and a corresponding decrease in the longline limit would increase net benefits from the groundfish fishery as a whole.

In this example and in general when the estimate of halibut bycatch cost based on losses to the groundfish fishery is greater than the estimate based on losses to the halibut fisheries, the halibut PSC limit is below the optimal level. The Council and Secretary have control over the PSC limits. If they are not expected to use that control to set PSC limits below the optimal levels, the estimate of halibut bycatch cost based on an estimate of foregone catch and benefits in the halibut fishery should be used. Conversely, if they are expected to set PSC limits below the optimal levels, the estimate of halibut bycatch cost based on an estimate of foregone catch and benefits in the other groundfish fishery should be used.

It is much more difficult to estimate halibut bycatch costs based on foregone catch and benefits for the other groundfish fisheries because the actual cost will depend on the actual halibut PSC allowances, the

TACs, the extent to which the TACs would be used fully in the absence of the halibut PSC limits, and halibut bycatch rates by fishery. Although such estimates are not used to estimate net benefit per ton of cod catch, Section 2.2.13 does address the potential differences between the two methods of estimating halibut bycatch costs.

The opportunity cost of groundfish bycatch is considered because, whether or not this bycatch is retained, it is counted against the TACs and, therefore, reduces the groundfish available to non-cod groundfish fisheries.

The gross FOB Alaska value per metric ton of catch for each groundfish species, other than cod, was calculated by estimating the FOB Alaska value of the products of that species that were retained in all non-cod BSAI groundfish fisheries and then dividing that value by the estimate of the total catch of that species in those fisheries. Table D8 contains the estimates of product value per metric ton of catch for each species and the data used to generate the estimates. The opportunity cost of each species was then calculated by taking 38% of the estimated product value per metric ton because the variable cost was estimated to be 62% of the FOB Alaska values. This variable cost estimate is based on cost and value data collected for the analysis of Amendment 18, the Inshore/Offshore allocation. It was assumed that all groundfish bycatch was subject to 100% mortality whether or not it was retained.

Estimates of the average opportunity cost of bycatch (AOCB) were generated by cod fishery, trimester, and year and within fishery by processor. The estimates by processor are used to determine the variability in the estimates due to differences among processors in terms of both the groundfish species composition of catch and bycatch rates. This variability provides a partial measure of the uncertainty associated with the 1991 and 1992 estimates of AOCB for each of the three cod fisheries. It also provides a means of determining the extent to which the estimates overlap for individual operations in different fisheries.

The estimate of groundfish bycatch cost is based on an estimate of the foregone value of that catch in other groundfish fisheries minus variable harvesting and processing costs. The prohibited species bycatch cost that would have occurred if that groundfish had been taken in other groundfish fisheries should also be subtracted. However, this cannot be done without knowing in what fisheries the groundfish catch was foregone, what the prohibited species bycatch rates are in those other groundfish fisheries, and what the per unit prohibited species bycatch costs are in those fisheries. For most of the other groundfish fisheries, this cost is small compared to the gross value of groundfish products net of variable costs. Therefore, the failure to make this adjustment is not expected to increase the estimates of groundfish bycatch costs substantially.

The assumption that all of the groundfish taken as bycatch in the cod fisheries would have otherwise been harvested in other groundfish fisheries also introduces an upward bias to the extent that the TACs of the bycatch species are not used fully. The estimates of groundfish bycatch cost by species and cod fishery (Appendix A, Table A51.1) allow for this problem to be addressed.

Table D1 BSAI cod fishery total and retained catch in metric tons by gear and species, 1991-92.

	Longline		Pot		Trawl	
	Catch	Retained	Catch	Retained	Catch	Retained
1991						
Pacific cod	74,852	73,455	5,200	5,027	80,521	77,729
Arrowtooth	1,999	79	1	0	3,273	265
Atka mack	3	0	1	0	840	81
Flat other	262	52	1	0	4,162	619
Pollock	2,386	125	1	0	35,917	4,939
Rock sole	18	1	0	0	5,915	1,570
Rockfish	245	178	1	0	2,875	2,217
Sablefish	455	444	0	0	18	15
Turbot	553	15	0	0	204	33
Yellowfin	3	0	2	0	611	23
Other	6,683	1,091	181	31	4,222	195
1992						
Pacific cod	97,084	95,355	11,817	11,726	41,603	38,410
Arrowtooth	1,620	60	3	0	2,634	139
Atka mack	46	21	9	0	3,175	1,031
Flat other	265	18	0	0	2,284	316
Pollock	3,104	96	6	0	13,718	2,164
Rock sole	27	4	2	0	3,226	1,128
Rockfish	807	422	3	0	1,244	476
Sablefish	225	204	13	13	9	9
Turbot	644	113	5	0	78	14
Yellowfin	86	0	12	0	494	158
Other	10,706	751	543	72	2,670	125

Note: The small number of weekly observations both for the cod trawl fishery in the second and third trimesters of 1991 and 1992 and for the cod pot fishery in the first trimester of 1991 are not included in these estimates because the samples were too small to provide meaningful estimates. Weekly observations by processor and gear for which there were not data from both the blend catch and WPR datasets were excluded as were observations for which total product weight exceeded total catch weight. These observations are also excluded from the other tables in this appendix and they were excluded in generating all of the estimates of net benefits per metric ton of cod catch. However, they are included in the Appendix A tables that present historical catch and production data.

Source: NMFS Alaska Region blend estimates.

Table D2 Product weight, product prices, and product values by species, product form code, and year for each of three BSAI cod fisheries, 1991-92.

Longline 1991

	Product weight (mt)	Price	Value ($1,000)
Pacific cod			
Whole fish/food fish	92.5	$.45	$91.6
Whole bait	295.1	$.45	$291.7
Bled only	.6	$.68	$.9
Gutted only	136.8	$.75	$225.5
H&G, Western cut	11,286.9	$.63	$15,642.4
H&G, Eastern cut	23,600.5	$.72	$37,667.7
Salted and split	135.0	$1.73	$514.3
Roe only	207.1	$1.02	$466.4
Pectoral girdle only	5.7	$.60	$7.6
Heads	32.8	$.40	$28.9
Cheeks	4.2	$.41	$3.8
Chins	.2	$.56	$.3
Fillets w/ skin and ribs	84.9	$1.95	$364.8
Fillets w/ skin, no ribs	1.7	$1.58	$5.8
Fillets w/ ribs, no skin	2.6	$2.24	$12.9
Fillets, no skin or ribs	52.2	$2.54	$292.6
Minced fish	7.1	$.58	$9.0
Fish meal	8.9	$.35	$6.9
Milt	17.8	$1.65	$64.6
Stomach(internal organs)	239.5	$.65	$341.5
Arrowtooth			
H&G, Eastern cut	26.7	$.22	$13.1
H&G, tail removed	21.2	$.39	$18.0
Kirimi	.1	$.26	$.1
Flat other			
Whole fish/food fish	1.9	$.42	$1.7
H&G, w/ roe	2.8	$1.86	$11.6
H&G, Western cut	2.7	$.79	$4.6
H&G, Eastern cut	7.5	$.84	$14.0
H&G, tail removed	2.9	$.77	$4.9
Pollock			
Whole fish/food fish	1.5	$.21	$.7
H&G, w/ roe	9.1	$.10	$2.0
H&G, Western cut	21.6	$.42	$20.1
H&G, Eastern cut	15.2	$.41	$13.6
H&G, tail removed	1.4	$.46	$1.4
Roe only	.1	$5.19	$1.5
Rock sole			
Gutted only	.2	$.27	$.1
H&G, w/ roe	.0	$1.47	$.1
H&G, Western cut	.0	$.72	$.1
H&G, Eastern cut	.3	$.92	$.7

Table D2 (Continued).

Longline 1991 continued

	Product weight (mt)	Price	Value ($1,000)
Rockfish			
Gutted only	.5	$1.34	$1.5
H&G, Western cut	3.8	$1.44	$12.0
H&G, Eastern cut	76.5	$1.71	$288.0
Chins	.0	$.98	$.1
Sablefish			
Gutted only	.0	$2.13	$.1
H&G, Western cut	5.0	$2.98	$32.8
H&G, Eastern cut	273.7	$2.84	$1,712.1
Turbot			
H&G, Western cut	.4	$1.00	$.9
H&G, Eastern cut	6.6	$2.37	$34.8
Other			
Whole fish/food fish	.4	$.59	$.5
Whole bait	.6	$.99	$1.4
Gutted only	2.1	$.52	$2.4
Wings	342.4	$.61	$461.5
Octopus/squid mantles	2.8	$.50	$3.1
Total	37,042.4	$55.64	$58,698.4

Pot 1991

Pacific cod			
Whole bait	126.6	$.45	$125.1
Gutted only	51.5	$.75	$84.9
H&G, Western cut	709.5	$.64	$997.4
H&G, Eastern cut	1,117.4	$.69	$1,689.3
Salted and split	141.1	$1.73	$537.3
Cheeks	7.2	$.41	$6.5
Chins	.5	$.56	$.6
Fillets w/ skin, no ribs	1.4	$1.58	$5.0
Fillets, no skin or ribs	41.9	$2.54	$234.4
Fish meal	2.1	$.35	$1.6
Other			
Whole fish/food fish	.7	$.59	$.9
Whole bait	3.7	$.99	$8.2
Total	2,203.6	$11.26	$3,691.2

Table D2 (Continued).

	Trawl 1991		
	Product weight (mt)	Price	Value ($1,000)
Pacific cod			
Whole fish/food fish	7,262.9	$.45	$7,190.8
Whole bait	182.7	$.45	$180.6
Bled only	893.6	$.68	$1,346.5
H&G, w/ roe	90.7	$.60	$120.2
H&G, Western cut	7,286.0	$.56	$8,992.0
H&G, Eastern cut	3,430.8	$.66	$4,955.5
H&G, tail removed	102.4	$.53	$120.7
Salted and split	5,669.9	$1.73	$21,595.1
Roe only	319.8	$1.02	$720.0
Pectoral girdle only	4.4	$.60	$5.8
Heads	3.4	$.40	$3.0
Cheeks	19.1	$.41	$17.3
Chins	4.4	$.56	$5.5
Belly flaps (meat)	.7	$.84	$1.2
Fillets w/ skin and ribs	519.4	$1.95	$2,232.1
Fillets w/ skin, no ribs	166.5	$1.58	$579.9
Fillets w/ ribs, no skin	214.9	$2.24	$1,060.0
Fillets, no skin or ribs	6,060.4	$2.54	$33,936.9
Minced fish	1,063.3	$.58	$1,358.7
Fish meal	2,203.4	$.35	$1,697.1
Fish oil	64.0	$.06	$8.5
Milt	12.9	$1.65	$46.8
Stomach(internal organs)	41.9	$.65	$59.7
Split, no backbones	73.5	$.88	$143.0
Bones	133.6	$.03	$9.2
Other	9.6	$.81	$17.0
Arrowtooth			
Whole fish/food fish	15.2	$.07	$2.3
H&G, Western cut	.1	$.28	$.1
H&G, Eastern cut	76.0	$.22	$37.2
H&G, tail removed	48.4	$.39	$41.1
Atka mack			
Whole fish/food fish	68.5	$.60	$91.3
H&G, Western cut	3.4	$.75	$5.6
H&G, Eastern cut	3.3	$.96	$7.0
Flat other			
Whole fish/food fish	50.6	$.42	$46.4
Gutted only	2.1	$.27	$1.3
H&G, w/ roe	97.1	$1.86	$397.7
H&G, Western cut	35.1	$.79	$60.9
H&G, Eastern cut	236.5	$.84	$440.2
Roe only	.2	$.60	$.3
Fish meal	6.4	$.24	$3.4

Table D2 (Continued).

Trawl 1991 continued

	Product weight (mt)	Price	Value ($1,000)
Pollock			
Whole fish/food fish	116.2	$.21	$53.9
H&G, Western cut	7.7	$.42	$7.1
H&G, Eastern cut	160.2	$.41	$143.7
Roe only	35.7	$5.19	$408.4
Fillets w/ skin and ribs	11.5	$1.31	$33.2
Fillets w/ skin, no ribs	.7	$.99	$1.4
Fillets w/ ribs, no skin	31.9	$1.36	$95.4
Fillets, no skin or ribs	636.7	$1.51	$2,119.6
Surimi	17.9	$1.42	$55.8
Minced fish	144.3	$.70	$222.0
Fish meal	211.9	$.26	$119.3
Split, no backbones	18.5	$1.10	$44.9
Rock sole			
Whole fish/food fish	39.4	$.49	$42.3
H&G, w/ roe	695.2	$1.47	$2,255.2
H&G, Western cut	115.5	$.72	$184.1
H&G, Eastern cut	206.6	$.92	$417.7
H&G, tail removed	10.1	$1.29	$28.8
Roe only	.1	$1.25	$.3
Fillets, no skin or ribs	8.9	$.60	$11.8
Rockfish			
Whole fish/food fish	498.8	$.62	$682.8
H&G, Western cut	54.3	$.71	$85.3
H&G, Eastern cut	695.3	$.80	$1,231.0
Pectoral girdle only	.1	$1.27	$.3
Fillets w/ skin and ribs	.1	$1.62	$.4
Sablefish			
H&G, Western cut	4.2	$2.98	$27.6
H&G, Eastern cut	9.5	$2.84	$59.7
Cheeks	.0	$.41	$.0
Chins	.0	$.45	$.0
Turbot			
Whole fish/food fish	.1	$.55	$.1
H&G, Eastern cut	11.6	$2.37	$60.5
H&G, tail removed	9.2	$1.25	$25.2
Yellowfin			
Whole fish/food fish	10.9	$.32	$7.8
Kirimi	7.9	$1.32	$23.1
Other			
Whole fish/food fish	14.3	$2.17	$68.6
Whole bait	2.0	$.99	$4.3
Gutted only	2.0	$.52	$2.2
Wings	53.4	$.61	$72.0
Octopus/squid mantles	.8	$.50	$.8
Total	40,320.2	$75.03	$96,134.2

Table D2 (Continued).

Longline 1992

	Product weight (mt)	Price	Value ($1,000)
Pacific cod			
Whole fish/food fish	23.9	$.45	$23.7
Whole bait	29.5	$.45	$29.2
Bled only	97.2	$.68	$146.4
Gutted only	8.5	$.75	$14.0
H&G, w/ roe	26.2	$.59	$34.1
H&G, Western cut	12,600.9	$.61	$16,817.2
H&G, Eastern cut	29,780.2	$.71	$46,920.5
Salted and split	42.6	$1.73	$162.4
Roe only	423.8	$1.02	$954.2
Heads	28.2	$.40	$24.9
Cheeks	1.6	$.41	$1.5
Fillets w/ skin, no ribs	.3	$1.58	$1.1
Fillets, no skin or ribs	800.1	$2.54	$4,480.2
Surimi	.7	$1.40	$2.0
Minced fish	149.9	$.58	$191.6
Fish meal	2.7	$.35	$2.1
Fish oil	.9	$.06	$.1
Milt	147.9	$1.65	$537.4
Stomach(internal organs)	133.1	$.65	$189.8
Bones	.2	$.03	$.0
Other	1.1	$.81	$2.0
Arrowtooth			
H&G, Eastern cut	21.0	$.22	$10.3
H&G, tail removed	15.5	$.39	$13.1
Atka mack			
H&G, Eastern cut	9.4	$.96	$19.9
Flat other			
H&G, w/ roe	.9	$1.86	$3.9
H&G, Western cut	.2	$.79	$.4
H&G, Eastern cut	8.0	$.84	$14.9
H&G, tail removed	.1	$.77	$.2
Pollock			
H&G, Eastern cut	31.5	$.41	$28.2
Roe only	1.1	$5.19	$12.4
Fillets, no skin or ribs	3.2	$1.51	$10.8
Minced fish	.3	$.70	$.5
Rock sole			
H&G, w/ roe	1.9	$1.47	$6.2
H&G, Eastern cut	3.8	$.92	$7.6
Kirimi	.4	$.95	$.9

Table D2 (Continued).

Longline 1992 continued

	Product weight (mt)	Price	Value ($1,000)
Rockfish			
Whole fish/food fish	1.5	$.70	$2.3
Gutted only	.2	$.70	$.4
H&G, Western cut	1.6	$1.42	$4.9
H&G, Eastern cut	168.3	$1.60	$594.1
Pectoral girdle only	2.5	$.74	$4.1
Cheeks	.0	$.90	$.0
Chins	.2	$.98	$.4
Other	.1	$1.10	$.2
Sablefish			
H&G, Western cut	1.4	$2.98	$8.9
H&G, Eastern cut	123.8	$2.84	$774.7
Roe only	1.9	$4.93	$20.9
Pectoral girdle only	.6	$.90	$1.2
Cheeks	.1	$.41	$.1
Chins	.7	$.45	$.7
Fish meal	.0	$.26	$.0
Other	.0	$.60	$.0
Turbot			
H&G, Western cut	.9	$1.00	$2.0
H&G, Eastern cut	42.0	$2.37	$219.6
H&G, tail removed	19.7	$1.25	$54.2
Kirimi	.4	$1.31	$1.1
Yellowfin			
H&G, Eastern cut	.2	$.48	$.2
Other			
Whole fish/food fish	.5	$.59	$.6
Whole bait	.4	$.99	$.8
Gutted only	18.1	$.52	$20.8
H&G, Eastern cut	32.3	$1.15	$81.7
Wings	193.9	$.61	$261.3
Octopus/squid mantles	.9	$.50	$1.0
Total	45,009.2	$66.69	$72,719.7

Table D2 (Continued).

Pot 1992

	Product weight (mt)	Price	Value ($1,000)
Pacific cod			
Whole fish/food fish	15.8	$.45	$15.6
Whole bait	48.0	$.45	$47.5
Bled only	10.0	$.68	$15.0
Gutted only	15.2	$.75	$25.0
H&G, Western cut	1,285.6	$.56	$1,579.8
H&G, Eastern cut	3,035.2	$.65	$4,366.8
H&G, tail removed	30.6	$.53	$35.5
Salted and split	347.5	$1.73	$1,323.6
Cheeks	32.9	$.41	$29.7
Fillets w/ skin, no ribs	.1	$1.58	$.3
Fillets, no skin or ribs	224.4	$2.54	$1,256.8
Minced fish	67.9	$.58	$86.8
Fish meal	131.3	$.35	$101.1
Fish oil	6.5	$.06	$.9
Bones	1.0	$.03	$.1
Other	19.1	$.81	$34.1
Rockfish			
H&G, Eastern cut	.2	$1.93	$1.0
Sablefish			
H&G, Eastern cut	9.0	$2.84	$56.6
Other			
Whole fish/food fish	.0	$.59	$.0
Whole bait	12.5	$.99	$27.2
Gutted only	24.1	$.52	$27.6
Octopus/squid mantles	3.1	$.50	$3.5
Total	5,320.1	$19.52	$9,034.4

Trawl 1992

	Product weight (mt)	Price	Value ($1,000)
Pacific cod			
Whole fish/food fish	673.7	$.45	$667.1
Whole bait	28.2	$.45	$27.8
Bled only	10.1	$.68	$15.3
H&G, Western cut	2,373.1	$.56	$2,918.8
H&G, Eastern cut	2,854.4	$.65	$4,084.9
Salted and split	876.3	$1.73	$3,337.4
Roe only	171.0	$1.02	$385.1
Pectoral girdle only	1.3	$.60	$1.8
Heads	14.6	$.40	$12.9
Cheeks	12.7	$.41	$11.5
Fillets w/ skin and ribs	593.5	$1.95	$2,550.4
Fillets w/ skin, no ribs	1.0	$1.58	$3.3
Fillets w/ ribs, no skin	159.7	$2.24	$787.9
Fillets, no skin or ribs	4,242.8	$2.54	$23,758.9
Surimi	123.0	$1.40	$378.8
Minced fish	1,135.2	$.58	$1,450.5
Fish meal	1,286.0	$.35	$990.6
Fish oil	13.4	$.06	$1.8
Milt	81.6	$1.65	$296.6
Stomach(internal organs)	.2	$.65	$.3
Bones	38.7	$.03	$2.7

Table D2 (Continued).

Trawl 1992 continued

	Product weight (mt)	Price	Value ($1,000)
1992			
Trawl			
Arrowtooth			
Whole fish/food fish	33.6	$.07	$5.2
H&G, Eastern cut	.2	$.22	$.1
H&G, tail removed	.2	$.39	$.1
Fish meal	11.9	$.25	$6.6
Atka mack			
Whole fish/food fish	83.3	$.60	$110.9
H&G, Western cut	.5	$.75	$.8
H&G, Eastern cut	564.1	$.96	$1,194.0
Fish meal	21.9	$.19	$9.3
Flat other			
Whole fish/food fish	43.0	$.42	$39.4
H&G, w/ roe	74.9	$1.86	$306.7
H&G, Eastern cut	49.9	$.84	$92.9
Fish meal	2.4	$.24	$1.3
Pollock			
Whole fish/food fish	27.2	$.21	$12.6
H&G, w/ roe	.5	$.10	$.1
H&G, Eastern cut	46.2	$.41	$41.5
H&G, tail removed	.4	$.46	$.4
Roe only	27.7	$5.19	$317.1
Fillets, no skin or ribs	202.1	$1.51	$672.8
Surimi	58.7	$1.42	$183.6
Minced fish	73.2	$.70	$112.7
Fish meal	46.6	$.26	$26.2
Fish oil	.9	$.06	$.1
Bones	1.7	$.05	$.2
Rock sole			
Whole fish/food fish	88.3	$.49	$95.0
Whole bait	6.6	$.50	$7.3
H&G, w/ roe	485.2	$1.47	$1,573.9
H&G, Western cut	3.0	$.72	$4.9
H&G, Eastern cut	105.2	$.92	$212.8
Fish meal	18.5	$.25	$10.4
Rockfish			
Whole fish/food fish	61.4	$.62	$83.7
H&G, Western cut	.3	$1.16	$.7
H&G, Eastern cut	179.7	$.85	$335.5
Pectoral girdle only	.0	$.64	$.0
Chins	.1	$.98	$.3
Fish meal	8.5	$.26	$4.9

Table D2 (Continued).

Trawl 1992 continued

	Product weight (mt)	Price	Value ($1,000)
Sablefish			
H&G, Eastern cut	5.8	$2.84	$36.1
Turbot			
H&G, Eastern cut	3.8	$2.37	$20.1
H&G, tail removed	2.8	$1.25	$7.8
Pectoral girdle only	.2	$.67	$.3
Yellowfin			
Whole fish/food fish	87.1	$.32	$62.3
H&G, Eastern cut	14.9	$.48	$15.8
Kirimi	22.4	$1.32	$65.4
Fish meal	7.3	$.26	$4.2
Other			
Whole fish/food fish	.0	$.59	$.1
Whole bait	.3	$.99	$.7
Gutted only	.6	$.52	$.7
Wings	7.8	$.61	$10.5
Fish meal	.7	$.24	$.4
Total	17,172.3	$58.43	$47,372.3

Longline H&G cod by trimester 1991

	Product weight (mt)	Price	Value ($1,000
Jan-May			
H&G, Western cut	3,652.7	$.64	$5,170.6
H&G, Eastern cut	10,222.9	$.74	$16,633.7
Jun-Aug			
H&G, Western cut	3,030.0	$.55	$3,693.4
H&G, Eastern cut	7,073.9	$.64	$10,058.6
Sep-Dec			
H&G, Western cut	4,604.2	$.67	$6,778.4
H&G, Eastern cut	6,303.7	$.79	$10,975.4

Pot H&G cod by trimester 1991

Jun-Aug			
H&G, Western cut	47.8	$.55	$58.3
H&G, Eastern cut	689.2	$.64	$980.0
Sep-Dec			
H&G, Western cut	661.7	$.64	$939.2
H&G, Eastern cut	428.2	$.75	$709.3

Trawl H&G cod by trimester 1991

Jan-May			
H&G, w/ roe	90.7	$.60	$120.2
H&G, Western cut	7,286.0	$.56	$8,992.0
H&G, Eastern cut	3,430.8	$.66	$4,955.5
H&G, tail removed	102.4	$.53	$120.7

Table D2 (Continued).

Longline H&G cod by trimester 1992	Product weight (mt)	Price	Value ($1,000)
Jan-May			
H&G, Western cut	6,826.0	$.64	$9,669.0
H&G, Eastern cut	18,166.7	$.75	$30,096.3
Jun-Aug			
H&G, w/ roe	26.2	$.59	$34.1
H&G, Western cut	5,103.7	$.55	$6,221.0
H&G, Eastern cut	9,974.8	$.64	$14,183.5
Sep-Dec			
H&G, Western cut	671.2	$.63	$927.2
H&G, Eastern cut	1,638.6	$.73	$2,640.7

Pot H&G cod by trimester 1992			
Jan-May			
H&G, Western cut	84.9	$.55	$103.5
H&G, Eastern cut	773.4	$.66	$1,122.0
H&G, tail removed	30.6	$.53	$35.5
Jun-Aug			
H&G, Western cut	1,122.7	$.55	$1,368.4
H&G, Eastern cut	2,111.2	$.64	$3,002.0
Sep-Dec			
H&G, Western cut	78.1	$.63	$107.9
H&G, Eastern cut	150.6	$.73	$242.7

Trawl H&G cod by trimester 1992			
Jan-May			
H&G, Western cut	2,373.1	$.56	$2,918.8
H&G, Eastern cut	2,854.4	$.65	$4,084.9

Note: For H&G cod, a base annual price was adjusted seasonally. The seasonal adjusters were: 0.90 for January-April, 0.75 for May-August, 0.85 for September-October, and 1.0 for November-December. The base annual prices were $0.86 per pound for the longline and pot fisheries and $0.73 per pound for the trawl fishery.

Sources: NMFS Alaska Region Weekly Processor Report data for 1991-92 and the ADF&G/CFEC/NMFS annual groundfish processor survey for 1991.

Table D3 BSAI cod catch, groundfish product weight divided by cod catch, FOB Alaska product value, and product value per metric ton of cod catch by cod fishery and trimester, 1991-92.

	Tons of cod	Total product weight per mt of cod catch	Product value	Value per ton
1991				
Longline				
Jan-May	27,250	.530	$23,038,184	$845.45
Jun-Aug	20,797	.523	$16,304,663	$783.99
Sep-Dec	26,805	.437	$19,355,582	$722.08
Annual	74,852	.495	$58,698,430	$784.19
Pot				
Jun-Aug	2,604	.353	$1,747,792	$671.10
Sep-Dec	2,595	.495	$1,943,409	$748.81
Annual	5,200	.424	$3,691,201	$709.89
Trawl				
Jan-May	80,521	.501	$96,134,238	$1,193.90
Annual	80,521	.501	$96,134,238	$1,193.90
1992				
Longline				
Jan-May	54,716	.475	$42,497,768	$776.70
Jun-Aug	36,451	.450	$25,654,320	$703.80
Sep-Dec	5,917	.437	$4,567,606	$771.97
Annual	97,084	.464	$72,719,694	$749.04
Pot				
Jan-May	3,343	.448	$3,399,899	$1,017.06
Jun-Aug	7,971	.446	$5,248,633	$658.43
Sep-Dec	502	.526	$385,900	$768.26
Annual	11,817	.450	$9,034,432	$764.56
Trawl				
Jan-May	41,603	.413	$47,372,334	$1,138.68
Annual	41,603	.413	$47,372,334	$1,138.68

Source: Tables D1 and D2.2

Table D4 Variable cost and overhead cost models for the cod fisheries.

Annual Data for a Factory Trawler H&G

Total product weight	5,500 mt (12.1 million lbs)
Cod product weight	500 mt (1.1 million lbs)
Total Groundfish value (FOB AK)	$7,580,000
Cod value	$ 890,000
Total fishing days	280
Cod fishing days	30
Operating days	305
Total fishing weeks	43
Overhead costs	
accounting	
legal/associations	
marketing	
admin/office	
insurance	
port fees/permits	
Total overhead	$ 565,200
Time Dependent Variable Costs	
fuel/oil	
maintenance/gear	
groceries	
crew transportation	
technicians	
communications	
Total	$1,269,400
Product Weight Dependent Variable Costs	
packaging/loading/unloading	
Total	$ 169,000
Crewshare	
crew and technicians	$1,667,600
Total Cost (a)	$3,671,200
Total Revenue - Total Cost (a)	$3,908,800

Summary of Cost Parameter Values for the Cost Model

Time dependent variable cost per fishing week	$29,500
Product weight dependent cost per pound of product	$0.0140
Labor cost per $ of product value (FOB Alaska)	$0.22
Annual overhead cost per week	$13,100
Annual overhead cost per pound of product	$0.0467
Annual overhead cost $ of product value	$0.0746

(a) total cost excluding debt service, depreciation, and return on investment

Table D4 Continued.

Annual Data for a Factory Trawler Fillets

Total product weight	3,821 mt (8.43 million lbs)
Cod product weight	588 mt (1.3 million lbs)
Total Groundfish value (FOB AK)	$13,100,000
Cod value	$ 2,661,000
Cod fishing days	58
Total fishing days	226
Operating days	240
Fishing weeks	32
<u>Overhead costs</u>	
accounting	
legal	
marketing	
admin/office	
insurance	
port fees/permits	
Total overhead	$1,217,700
<u>Time Dependent Variable Costs</u>	
fuel/oil	
maintenance/gear	
groceries	
crew transportation	
technicians	
Total	$1,854,000
<u>Product Weight Dependent Variable Costs</u>	
packaging	
loading/unloading	
Total	$ 339,900
<u>Crewshare</u>	
crew	$3,871,000
<u>Total Cost (a)</u>	$7,282,600
<u>Total Revenue - Total Cost (a)</u>	$5,817,400

<u>Summary of Cost Parameter Values for the Cost Model</u>

Time dependent variable cost per fishing week	$57,900
Product weight dependent cost per pound of product	$0.0403
Labor cost per $ of product value (FOB Alaska)	$0.2955
Annual overhead cost per week	$38,100
Annual overhead cost per pound of product	$0.1444
Annual overhead cost $ of product value	$0.0930

(a) total cost excluding debt service, depreciation, and return on investment

Table D4 Continued.

Annual Data for a Large Factory Longliner H&G

Total product weight	2,272 mt (5.01 million lbs)
Cod product weight	2,272 mt (5.01 million lbs)
Total Groundfish value (FOB AK)	$4,377,400
Cod value	$4,377,400
Total fishing days	225
Cod fishing days	225
Operating days	260
Fishing weeks	37
<u>Overhead costs</u>	
accounting	
legal	
marketing	
admin/office staff	
insurance	
port fees/permits	
Total overhead	$ 419,500
<u>Time Dependent Variable Costs</u>	
fuel/oil	
maintenance/gear	
groceries	
crew transportation	
technician	
bait	
Total	$1,120,900
<u>Product Weight Dependent Variable Costs</u>	
packaging/loading/unloading	$ 70,100
Total	$ 70,100
<u>Crewshare</u>	
crew	$1,022,900
<u>Total Cost (a)</u>	$2,633,400
<u>Total Revenue - Total Cost (a)</u>	$1,744,000

<u>Summary of Cost Parameter Values for the Cost Model</u>	
Time dependent variable cost per fishing week	$30,300
Product weight dependent cost per pound of product	$0.0140
Labor cost per $ of product value (FOB Alaska)	$0.2337
Annual overhead cost per week	$11,300
Annual overhead cost per pound of product	$0.0837
Annual overhead cost $ of product value	$0.0958

(a) total cost excluding debt service, depreciation, and return on investment

Table D4 Continued.

Annual Data for a Small Factory Longliner H&G

Total product weight	1,510 mt (3.33 million lbs)
Cod product weight	1,510 mt (3.33 million lbs)
Total Groundfish value (FOB AK)	$3,588,000
Cod value	$3,588,000
Total fishing days	231
Cod fishing days	231
Operating days	365
Fishing weeks	44
<u>Overhead costs</u>	
accounting	
legal	
marketing	
admin/office staff	
insurance	
port fees/permits	
Total overhead	$ 676,000
<u>Time Dependent Variable Costs</u>	
fuel/oil	
maintenance/gear	
groceries	
crew transportation	
technician	
bait/storage	
Total	$1,134,500
<u>Product Weight Dependent Variable Costs</u>	
packaging/loading/unloading	$ 46,600
Total	$ 46,600
<u>Crewshare</u>	
crew	$1,184,000
<u>Total Cost (a)</u>	$3,041,100
<u>Total Revenue - Total Cost (a)</u>	$ 546,900

<u>Summary of Cost Parameter Values for the Cost Model</u>	
Time dependent variable cost per fishing week	$25,800
Product weight dependent cost per pound of product	$0.0140
Labor cost per $ of product value (FOB Alaska)	$0.33
Annual overhead cost per week	$15,400
Annual overhead cost per pound of product	$0.2030
Annual overhead cost $ of product value	$0.1884

(a) total cost excluding debt service, depreciation, and return on investment

Table D4

Data for Ten Trips for a Medium Factory Longliner H&G

Total product weight	2,667 mt (5.88 million lbs)
Cod product weight	2,667 mt (5.88 million lbs)
Total Groundfish value (FOB AK)	$6,009,000
Cod value	$6,009,000
Total fishing days	319
Cod fishing days	319
Operating days	375
Fishing weeks	56
Overhead costs	
accounting	
legal	
marketing	
admin/office staff	
insurance	
port fees/permits	
Total overhead	$ 446,600
Time Dependent Variable Costs	
fuel/oil	
maintenance/gear	
groceries	
crew transportation	
technician	
bait	
Total	$ 978,500
Product Weight Dependent Variable Costs	
packaging/loading/unloading	$ 82,300
Total	$ 82,300
Crewshare	
crew	$2,056,300
Total Cost (a)	$3,563,700
Total Revenue - Total Cost (a)	$2,445,300

Summary of Cost Parameter Values for the Cost Model	
Time dependent variable cost per fishing week	$17,500
Product weight dependent cost per pound of product	$0.0140
Labor cost per $ of product value (FOB Alaska)	$0.3422
Annual overhead cost per week	$8,000
Annual overhead cost per pound of product	$0.0760
Annual overhead cost $ of product value	$0.0743

(a) total cost excluding debt service, depreciation, and return on investment

Table D4 Continued.

Average Trip Data for a Factory Pot Boat H&G

Total product weight	72.9 mt (160,700 lbs)	
Cod product weight	72.9 mt (160,700 lbs)	
Total Groundfish value (FOB AK)	$144,600	
Cod value	$144,600	
Total fishing days	11	
Cod fishing days	11	
Operating days	15	
Fishing weeks	2	
<u>Overhead costs</u>		
accounting		
legal		
marketing		
admin/office staff		
insurance		
port fees/permits		
Total overhead	$ 14,000	
<u>Time Dependent Variable Costs</u>		
fuel/oil		
maintenance/gear		
groceries		
crew transportation		
technician		
bait		
Total	$ 28,815	
<u>Product Weight Dependent Variable Costs</u>		
packaging/loading/unloading	$ 2,250	
Total	$ 2,250	
<u>Crewshare</u>		
crew	$ 48,170	
<u>Total Cost (a)</u>	$ 93,235	
<u>Total Revenue - Total Cost (a)</u>	$ 51,365	
<u>Summary of Cost Parameter Values for the Cost Model</u>		
Time dependent variable cost per fishing week		14,400
Product weight dependent cost per pound of product		0.014
Labor cost per $ of product value (FOB Alaska)		0.333
Annual overhead cost per week		7,000
Annual overhead cost per pound of product		0.0871
Annual overhead cost $ of product value		0.0968

(a) total cost excluding debt service, depreciation, and return on investment

Table D4 Continued.

The following three cost models were run for each fillet factory trawler.

Cost Model 1 for Fillet Factory Trawler

OC1 = weeks x 28,575
OC2 = prod pounds x 0.1083
OC3 = prod value x 0.070
VC = weeks x 43,425 + prod pounds x 0.0403 + prod value x 0.2955

where weeks, prod pounds, and prod value are for cod weeks.
****
Cost Model 2 Fillet Factory Trawler

OC1 = weeks x 38,100
OC2 = prod pounds x 0.1444
OC3 = prod value x 0.093
VC = weeks x 57,900 + prod pounds x 0.0403 + prod value x 0.2955

****
Cost Model 3 Fillet Factory Trawler

OC1 = weeks x 47,625
OC2 = prod pounds x 0.1805
OC3 = prod value x 0.1163
VC = weeks x 72,375 + prod pounds x 0.0403 + prod value x 0.2955

****
The following three cost models were run for each H&G factory trawler.

Cost Model 1 for H&G Factory Trawler

OC1 = weeks x 9,825
OC2 = prod pounds x 0.0350
OC3 = prod value x 0.0560
VC = weeks x 22,125 + prod pounds x 0.014 + prod value x 0.22

****
Cost Model 2 for H&G Factory Trawler

OC1 = weeks x 13,100
OC2 = prod pounds x 0.0467
OC3 = prod value x 0.0746
VC = weeks x 29,500 + prod pounds x 0.014 + prod value x 0.22

****
Cost Model 3 for H&G Factory Trawler

OC1 = weeks x 16,375
OC2 = prod pounds x 0.0584
OC3 = prod value x 0.0933
VC = weeks x 36,875 + prod pounds x 0.014 + prod value x 0.22

Table D4 continued.

The following three cost models were run for each factory longliner.

Cost Model 1 for H&G Factory Longliner

OC1 = weeks x 8,000
OC2 = prod pounds x 0.076
OC3 = prod value x 0.0743
VC = weeks x 17,500 + prod pounds x 0.014 + prod value x 0.3422

****
Cost Model 2 for H&G Factory Longliner

OC1 = weeks x 11,300
OC2 = prod pounds x 0.0837
OC3 = prod value x 0.0958
VC = weeks x 30,300 + prod pounds x 0.014 + prod value x 0.2337

****
Cost Model 3 for H&G Factory Longliner

OC1 = weeks x 15,400
OC2 = prod pounds x 0.203
OC3 = prod value x 0.1884
VC = weeks x 25,800 + prod pounds x 0.014 + prod value x 0.33

****
The following three cost models were run for each factory pot boat.

Cost Model 1 for Factory Pot Boat

OC1 = weeks x 5,250
OC2 = prod pounds x 0.0653
OC3 = prod value x 0.0726
VC = weeks x 10,800 + prod pounds x 0.014 + prod value x 0.333

****
Cost Model 2 for Factory Pot Boat

OC1 = weeks x 7,000
OC2 = prod pounds x 0.0871
OC3 = prod value x 0.0968
VC = weeks x 14,400 + prod pounds x 0.014 + prod value x 0.333

****
Cost Model 3 for Factory Pot Boat

OC1 = weeks x 8,750
OC2 = prod pounds x 0.1089
OC3 = prod value x 0.1210
VC = weeks x 18,000 + prod pounds x 0.014 + prod value x 0.333

Table D5 Values of the aggregate variables used in the variable cost models.

Number of Weeks

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline	264	241	325	830
Pot	.	25	30	55
Fillet trawl	93	.	.	93
H & G trawl	144	.	.	144
All trawl	237	.	.	237
1992				
Longline	519	456	94	1,069
Pot	29	138	21	188
Fillet trawl	85	.	.	85
H & G trawl	74	.	.	74
All trawl	159	.	.	159
1991-92				
Longline	783	697	419	1,899
Pot	29	163	51	243
Fillet trawl	178	.	.	178
H & G trawl	218	.	.	218
All trawl	396	.	.	396

Product Weight (1,000 lbs)

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline	31,721	22,730	25,299	79,750
Pot	.	1,625	2,385	4,011
Fillet trawl	11,452	.	.	11,452
H & G trawl	21,278	.	.	21,278
All trawl	32,730	.	.	32,730
1992				
Longline	57,052	35,883	5,691	98,626
Pot	1,798	6,416	534	8,748
Fillet trawl	11,721	.	.	11,721
H & G trawl	10,499	.	.	10,499
All trawl	22,220	.	.	22,220
1991-92				
Longline	88,773	58,613	30,990	178,376
Pot	1,798	8,042	2,920	12,759
Fillet trawl	23,173	.	.	23,173
H & G trawl	31,778	.	.	31,778
All trawl	54,950	.	.	54,950

Table D5 (Continued).

Product Value

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline	$22,899,598	$14,207,596	$19,055,398	$56,162,591
Pot	.	$1,039,406	$1,634,201	$2,673,607
Fillet trawl	$21,309,927	.	.	$21,309,927
H & G trawl	$17,025,216	.	.	$17,025,216
All trawl	$38,335,143	.	.	$38,335,143
1992				
Longline	$42,062,387	$25,272,949	$4,562,099	$71,897,436
Pot	$1,165,565	$3,958,065	$360,999	$5,484,629
Fillet trawl	$19,566,550	.	.	$19,566,550
H & G trawl	$7,632,296	.	.	$7,632,296
All trawl	$27,198,846	.	.	$27,198,846
1991-92				
Longline	$64,961,985	$39,480,545	$23,617,498	$128,060,027
Pot	$1,165,565	$4,997,471	$1,995,200	$8,158,236
Fillet trawl	$40,876,476	.	.	$40,876,476
H & G trawl	$24,657,512	.	.	$24,657,512
All trawl	$65,533,989	.	.	$65,533,989

Cod Catch in Metric Tons

	Jan-May	Jun-Aug	Sep-Dec	Annual
1991				
Longline	27,111	19,973	26,542	73,626
Pot	.	2,166	2,335	4,501
Fillet trawl	18,365	.	.	18,365
H & G trawl	15,647	.	.	15,647
All trawl	34,012	.	.	34,012
1992				
Longline	54,539	36,117	5,911	96,567
Pot	1,929	6,616	474	9,019
Fillet trawl	17,987	.	.	17,987
H & G trawl	8,327	.	.	8,327
All trawl	26,314	.	.	26,314
1991-92				
Longline	81,650	56,090	32,453	170,193
Pot	1,929	8,782	2,809	13,520
Fillet trawl	36,352	.	.	36,352
H & G trawl	23,974	.	.	23,974
All trawl	60,326	.	.	60,326

Sources: NMFS Alaska Region blend estimates, Weekly Processor Report data, and the ADF&G/CFEC/NMFS annual groundfish processor survey for 1991.

Table D6 Estimated opportunity cost per unit of prohibited species bycatch.

Parameter Values

Discard mortality rates

	Halibut	Herring	Bairdi	Salmon	King crab
Cod LGL	20%	100%	45%	100%	37%
Cod Pot	5%	100%	30%	100%	37%
Cod TWL	60%	100%	80%	100%	80%

Foregone catch/unit of bycatch mortality

	Range		
Halibut			
Longline	1	1.09	(pounds/pound)
Pot	1	1.05	(pounds/pound)
Trawl	1	1.69	(pounds/pound)
Herring	0	0.88	(pounds/pound)
Bairdi	0	0.76	(pounds/crab)
Salmon	0	13.2	(pounds/salmon)
King crab	0	3.5	(pounds/crab)

Other parameter values

	Halibut	Herring	Bairdi	Salmon	King crab
Product recovery rate	0.75	1.00	0.47	0.77	0.57
FOB AK price ($/lb)	1.45	0.62	3.30	3.95	9.85
Variable cost factor	0.47	0.49	0.61	0.42	0.54

Opportunity cost/unit bycatch (dollars)

	Longline		Pot		Trawl	
	Low	High	Low	High	Low	High
Pacific halibut	254	277	64	67	762	1,288
Herring	0	613	0	613	0	613
Bairdi	0	0.21	0	0.14	0	0.37
Salmon	0	23.29	0	23.29	0	23.29
King crab	0	3.34	0	3.34	0	7.23

Note: These estimates of the opportunity cost per unit of prohibited species bycatch were used for both 1991 and 1992.

Table D7 Estimated annual and total yield loss in the halibut fishery (mt) per metric ton of halibut bycatch mortality in the 1990 cod fisheries for discount rates of 0%, 5%, 7%, and 9%.

Year	Combined Yield Loss			Discounted @ 5%			Discounted @ 7%			Discounted @ 9%		
	Lgl	Twl	Pot	Lgl	Twl	Pot	Lgl	Twl	Pot	Lgl	Twl	Pot
1990	0.073	0.021	0.088	0.073	0.021	0.088	0.073	0.021	0.088	0.073	0.021	0.088
1991	0.844	1.058	0.812	0.804	1.008	0.773	0.789	0.989	0.759	0.774	0.971	0.745
1992	-0.005	-0.112	0.005	-0.005	-0.102	0.005	-0.004	-0.098	0.004	-0.004	-0.094	0.004
1993	0.024	-0.027	0.033	0.021	-0.023	0.029	0.020	-0.022	0.027	0.019	-0.021	0.025
1994	0.044	0.098	0.053	0.036	0.081	0.044	0.034	0.075	0.040	0.031	0.069	0.038
1995	0.054	0.148	0.047	0.042	0.116	0.037	0.039	0.106	0.034	0.035	0.096	0.031
1996	0.053	0.184	0.034	0.040	0.137	0.025	0.035	0.123	0.023	0.032	0.110	0.020
1997	0.044	0.187	0.035	0.031	0.133	0.025	0.027	0.116	0.022	0.024	0.102	0.019
1998	0.043	0.171	0.027	0.029	0.116	0.018	0.025	0.100	0.016	0.022	0.086	0.014
1999	0.024	0.145	0.025	0.015	0.093	0.016	0.013	0.079	0.014	0.011	0.067	0.012
2000	0.024	0.119	0.017	0.015	0.073	0.010	0.012	0.060	0.009	0.010	0.050	0.007
2001	0.024	0.095	0.016	0.014	0.056	0.009	0.011	0.045	0.008	0.009	0.037	0.006
2002	0.014	0.075	0.013	0.008	0.042	0.007	0.006	0.033	0.006	0.005	0.027	0.005
2003	0.013	0.059	0.009	0.007	0.031	0.005	0.005	0.024	0.004	0.004	0.019	0.003
2004	0.012	0.045	0.004	0.006	0.023	0.002	0.005	0.017	0.002	0.004	0.013	0.001
2005		0.032			0.015			0.012			0.009	
2006		0.019			0.009			0.006			0.005	
2007		0.009			0.004			0.003			0.002	
Total	1.285	2.326	1.218	1.136	1.832	1.093	1.090	1.689	1.053	1.048	1.569	1.017

Source: The estimates of annual yield loss were provided by Sara Adlerstein, International Pacific Halibut Commission. The discounted present values of those estimates were calculated by the NMFS.

Table D8 Estimates of total catch, total product value, and value per metric ton of catch by species for the BSAI groundfish fisheries excluding the cod fisheries, 1991-92.

	Catch	Product Value	Value per mt
1991			
Arrowtooth	15,344	858,898	56
Atka mack	25,855	23,321,056	902
Flat other	31,493	6,922,003	220
Pollock	1,586,294	918,429,839	579
Rock sole	50,118	36,766,242	734
Rockfish	7,101	4,651,024	655
Sablefish	2,902	10,704,940	3,688
Turbot	7,461	11,109,649	1,489
Yellowfin	116,984	67,863,738	580
Other	15,280	526,670	34
1992			
Arrowtooth	7,529	89,099	12
Atka mack	46,791	40,173,665	859
Flat other	32,287	5,495,255	170
Pollock	1,421,008	857,092,164	603
Rock sole	48,630	32,743,524	673
Rockfish	16,352	11,040,817	675
Sablefish	1,841	6,550,038	3,559
Turbot	1,991	1,202,793	604
Yellowfin	146,335	79,321,572	542
Other	19,271	541,758	28

Source: 1991 NMFS Alaska Region weekly processor report,
1992 NMFS Alaska Region product file,
1991-92 NMFS Alaska Region blend estimates.

Sources: 1991 NMFS Alaska Region weekly processor report, 1992 NMFS Alaska Region product file, 1991-92 NMFS Alaska Region blend estimates, and ADF&G/CFEC/NMFS 1991 annual processor survey.

APPENDIX E

ASSESSMENT OF FISHERY SELECTIVITY PATTERNS FOR PACIFIC COD IN THE EASTERN BERING SEA

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Introduction

Fish of different sizes and ages usually are not captured in their true proportions. These patterns of selectivity determine the age at which fish are typically harvested and affect the potential yield from the stock. In this document, the size composition of Pacific cod in the eastern Bering Sea's trawl, longline, and pot fisheries and in the trawl survey are examined, and a size- and age-structured assessment model is used to estimate selectivity by comparing these observed size compositions (Figure 1) to estimates of the cod population's size composition. This size- and age-structured assessment model is more detailed than the age-structured model used in the 1992 Pacific cod stock assessment. It will provide overall results that are comparable to the age-structured model, but by directly using the greater number of size composition observations it should provide more precise estimates of selectivity patterns.

The term "selectivity" can be ambiguous. The probability of capture for fish of different ages/sizes depends upon a large number of factors including geographic and temporal segregation, targeting by fishermen on desirable aggregations of fish, mesh size, and gear avoidance. Sometimes these patterns are split into vulnerability and selectivity. Vulnerability indicates the fraction of the fish of a particular age/size that could be caught if a very high level of effort was exerted. Selectivity indicates the degree of difficulty in catching fish of a particular age/size relative to other ages/sizes. If very high effort is exerted, all vulnerable fish will be caught no matter how low their level of selectivity, but the distinction between vulnerability and selectivity has no significant impact at low to moderate levels of exploitation. In practice, the biological and technological factors that cause selectivity and vulnerability blur together. Here, all patterns are examined solely as selectivity.

Synthesis Model

The Synthesis model simulates the dynamics of an age-structured exploited population and simulates the processes by which the fisheries and surveys affect and observe this population (Methot, 1990). The model adjusts parameters (such as annual recruitment, fishing mortality, selectivity patterns) to maximize the quality of the model's fit to various kinds of data (survey biomass, fishery size and age composition). The result should be a description of the population that is consistent with each type of data, but smoothes out the measurement variability associated with the observations. In practice the various types of data may indicate patterns that are inconsistent with each other. Here the model is perhaps even more useful by providing a framework for identifying and exploring these discrepancies.

The age-structured version of Synthesis basically assumes that all fish of a given age can be adequately described by a mean body weight and a mean selectivity. Its simulation can be briefly described as:

N_{ya} = population numbers in year y and age a (note that multiple periods within year can be defined)

M = instantaneous rate of natural mortality

W_{yat} = body weight at age observed for fishery type t

S_{at} = gear and age-specific selectivity (note that selectivity patterns can be changed over time)

E_{yt} = fishing mortality rate in year y, fishery t for fully available ages (e.g. ages for which $S_{at} = 1.0$)

$F_{yat} = E_{yt}S_{at}$ = fishing mortality rate by year, fishery, and age

$Z_{ya} = M + \Sigma_t F_{yat}$ = total mortality rate

$$c_{yat} = N_{ya} \frac{F_{yat}}{Z_{ya}} (1-e^{-Z_{ya}}) = \text{catch at age}$$

$$C_{yt} = \Sigma_a \, c_{yat} W_{yat} = \text{catch biomass}$$

$$N_{y+1,a+1} = N_{ya} \, e^{-Z_{ya}} \quad \text{(with accumulation in the terminal age).}$$

The age-structured synthesis model is primarily designed to examine age composition data, but it is able to calculate expected length compositions by applying a length at age distribution, $L@A_{al}$, to the estimate of the catch at age. However, the age-structured model does not explicitly model growth, nor does it allow fishery selectivity to vary by size, rather than age.

The size-structured synthesis model maintains all the characteristics of the age-structured model, but adds a length dimension to the existing time and age dimensions. The population age composition is expanded into the population age/length composition through use of the same sort of length at age matrix (Figure 2), $L@A_{al}$, used in the age-structured model. However, the size model is designed to adjust the growth parameters that describe this matrix. Selectivities are defined as a function of size and applied to the size- and age-structured population to generate estimates of the size and age composition of the catch.

$N'_{yal} = L@A_{al} \, N_{ya}$ = numbers at age/length in year *y*

where:

$L@A_{al}$ is the proportion of the age *a* fish that are in the l^{th} size bin; assumes that mean size at age in the true population can be described by a von Bertalanffy growth function and that the distribution of size at age is normal

N_{ya} is the mean numbers at age during time period *y*.

The age- and size-structured population is acted on by fisheries and surveys described by size-specific selectivity, S_{lt}, patterns. The catch at age/length is then simply:

$$C_{yalt} = S_{lt} \, N'_{yal}.$$

Row and column sums of the estimated catch at age/length then indicate the expected proportion at length and proportion at age:

$$p_{lt} = \frac{\Sigma_a \, C_{yalt}}{\Sigma_{al} \, C_{yalt}} \text{ is proportion at length;}$$

$$p_{at} = \frac{\Sigma_l \, C_{yalt}}{\Sigma_{al} \, C_{yalt}} \text{ is proportion at age.}$$

The calculated mean body weight at age for each fishery depends on the size-specific selectivity and on the distribution of size at age:

W_l is the mean weight of fish in the l^{th} size bin

W_{at} is the estimated mean weight of age a fish in fishery t

$$W_{at} = \frac{\Sigma_l S_{lt} L@A_{al} W_l}{\Sigma_l S_{lt} L@A_{al}}$$

Methot (1990) also indicates how the C_{yalt} matrix can be converted into estimates of mean body length at age that take into account size-selectivity and variability in the ageing process.

<u>EBS Pacific Cod Data</u>

The fishery data were stratified by gear type (trawl, longline, and pot) and by season (January-May, June-August, and September-December). Retained catch biomass, discarded catch biomass, and catch size composition were calculated for each stratum.
In order to track any changes in fishery selectivity patterns, the model estimated separate patterns for each of several time periods:

Jan-May Trawl:	1978-1983	1984-1989		1990-1992
Jun-Dec Trawl:	1978-1983	1984-1985	1986-1989	1990-1992
Longline:	1978-1983	1984-1989		1990-1992
Pot:				1988-1992.

Prior to 1984, the seasonal size composition data for longline and June-December trawl were aggregated into annual data to increase the sample size and assigned to the June-August time period. Size composition data from the 1977-1979 trawl fishery were not included in the model because the patterns varied erratically due to small sample sizes. Other size composition observations were not included in the model if the number of fish measured was less than about 1000 fish. Beginning in 1984 the sample size tended to increase and a new selectivity era was defined to prevent the noisier early data from influencing the selectivity pattern estimated for the post-1984 period. An extra time period for the June-Dec trawl fishery was implemented because inspection of the data indicated that the 1984 and 1985 summer trawl fisheries captured a higher than average proportion of small cod. The final selectivity period was started in 1990 for all trawl and longline fisheries to provide selectivity estimates focused on the recent domestic fisheries.

The survey data included the estimated biomass and size composition (Figure 3) for the years 1979-1992. Growth of younger cod is well represented by the progression of the first three size modes which occur at about 18, 32, and 44 cm during the summer.

Some age data are available for Pacific cod in the eastern Bering Sea, and age composition estimates for the fisheries and bottom trawl survey have been made for all years in order to apply age-structured assessment models. These age data and estimates were not included in the current model in order to focus model results on the size-specific fishery selectivity patterns. However, observed mean size at age for ages 6 to 12 in years 1988 to 1992 was determined from otoliths and used in the model to provide information on the growth of older Pacific cod.

The time series of biomass indicates an increase from 1979-1981 and a decrease from 1989-1991. The size composition data from the survey (Figure 3) exhibit modes which, when tracked over time, indicate growth rates and relative year class size. The increasing biomass during 1979-1981 seems due to recruitment of the 1977 year class. The sustained high biomass during the late 1980s seems due to recruitment of the 1982 and 1984 year classes. The recent decline in biomass is a result of weak recruitment from the 1985-1988 year classes. Finally, distinct modes of small fish in the 1990-1992 surveys suggest increased recruitment and future increases in biomass. Size modes which are consistent with the 1977, 1982, 1984, and 1989 year classes also occur in the fishery size composition data (Figure 4-7). The Size Synthesis model is used to quantify these patterns, to infer the most likely population size composition in each time period, and to estimate the fishery selectivity patterns that relate the estimated population size composition to the observed fishery size compositions.

Model Fit to Data

The model tracks closely the observed biomass from the bottom trawl survey (Figure 8). The largest deviation occurs in 1979 and the mean deviation (root mean squared log deviation) is only 0.114. This is approximately equivalent to a CV of 11.4% and indicates that the model's fit to the surveys is about as good as the typical estimated level of precision for the surveys. The patterns in the survey size composition are also matched closely (Figure 9), especially during 1988-1992 (Figure 10). The size composition data from the three gear types are also matched with a high level of precision (Figures 11-13), especially given the assumption of constant selectivity during each of the eras described above. The model's ability to match simultaneously the trends in biomass and the modes in the size composition indicates a high level of consistency between these types of data.

The size modes apparent at approximately 18, 32, and 44 cm correspond to the first three age groups in the Pacific cod population (see also Lai et al., 1987; Kimura and Lyons, 1990). The size modes for some stronger year classes can be followed for about 5 years (Figure 3). The model estimates that large year classes originated in 1977, 1982, 1984, and that year classes of slightly lower magnitude occurred in 1978, 1989, and 1990 (Figure 14). The model estimates that population biomass reached a peak of about 1.5 million t in 1983. This is somewhat greater than the peak estimate of survey biomass (1.2 million t) because the model estimates that the larger cod are only 60% available to the bottom trawl survey. This decline in selectivity may be due to gear avoidance or to incomplete coverage of the continental slope.

Estimated Fishery Selectivity

The current estimates of fishery selectivity are asymptotic at larger sizes for all gear types (Figure 15). In earlier investigations, the model indicated that fishery selectivity declined for the largest fish. This dome-shaped pattern is not necessarily counter-intuitive. While capture of large fish certainly is desirable, lower selectivity still could occur because of gear factors (trawl avoidance, hook size, pot tunnel entrance size) or by targeting fishing effort on areas with high catch per unit effort which may have disproportionately more small fish. The change to an estimated asymptotic selectivity pattern produces only a slight improvement in the model's fit to the data and is accompanied by a decrease in the estimate of mean maximum size for Pacific cod. The change has little effect on model forecasts of potential yield because it only affects fish larger than about 85 cm.

The estimates of selectivity for small cod differ between the gear types. Cod smaller than 50 cm are most commonly caught by the trawl fishery during the January-May period (Figure 15). The trawl fishery during the remainder of the year and the longline fishery throughout the year had similar patterns of selectivity in 1990-1992. Size at 50% selectivity is delayed by about 10 cm for the pot fishery. In earlier time periods the size-selectivity patterns are similar with the exception of the summer trawl fishery in 1984-1985:

Size at 50% selectivity

Era:	1978-1983	1984-1985	1986-1989	1990-1992
Jan-May Trawl:	56 cm	56	same	52
Jun-Dec Trawl:	64	39	59	54
Longline:	64	55	same	54
Pot:				64.

Longline and pot fisheries were assumed to have the same size-specific selectivity throughout the year. The good fits to the seasonal size composition data (Figures 12-13) do not indicate any need to introduce seasonality in the selectivity patterns for these fisheries. Although size-specific selectivity is constant throughout the year, mean age-specific selectivity (Figure 16) increases because the fish are growing. The estimated age-specific selectivities in 1992 are:

January-May	1	2	3	4	5	6	7	8	9	10	11	12
TRAWL	0%	1	14	42	66	82	91	96	98	98	99	99
LLINE	0	0	3	32	68	88	96	98	99	99	99	99
POT	0	0	0	8	29	55	73	84	91	93	96	97
June-August												
TRAWL	0	1	12	46	74	88	94	97	98	99	99	99
LLINE	0	0	8	45	77	92	97	98	99	99	99	99
POT	0	0	1	14	38	62	78	87	92	94	96	98
September-December												
TRAWL	0	2	18	54	79	91	95	97	98	99	99	99
LLINE	0	0	13	55	82	94	97	99	99	99	99	99
POT	0	0	3	19	44	66	80	88	92	95	96	98

The mean body weights (in kg x 10) at age are:

March	1	2	3	4	5	6	7	8	9	10	11	12
POPUL	0	2	8	18	29	40	52	63	74	81	91	102
TRAWL	0	3	10	20	31	42	53	64	74	82	91	103
LLINE	0	6	12	22	31	42	53	64	74	81	91	102
POT	0	2	16	24	35	45	56	66	76	83	92	103
July												
TRAWL	1	5	14	24	35	46	57	67	77	84	93	104
LLINE	1	8	15	25	35	45	56	67	77	84	93	104
POT	1	4	18	28	38	49	59	69	79	86	94	105
October												
TRAWL	2	7	16	27	37	48	59	70	79	86	95	105
LLINE	1	9	17	27	37	48	59	70	79	86	95	105

For comparison, the body weights at age (for all fisheries at the beginning of the year) used in the previous, age-structured assessment are:

1	2	3	4	5	6	7	8	9	10	11	12
-	-	7	14	24	35	48	61	74	87	100	112.

Computation of Yield Per Recruit

Population life history parameters were used along with selectivity estimates obtained from Synthesis modeling to compute equilibrium yield per recruit under alternative management regimes. It was assumed that the stock would be harvested at the $F_{35\%}$ rate, that is, at the instantaneous fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the pristine (equilibrium unfished) level. In addition to the parameters described in Section 3.1.2 and this appendix, computation of $F_{35\%}$ requires an estimate of the maturity-at-age schedule. Two alternative schedules were used for the present analysis. In the first schedule, 50% of the fish are mature by the time they reach 61 cm in length, while in the second schedule, 50% are mature by 48 cm. The full schedules are shown below (ages are in years, maturities are in percent):

Age:	3	4	5	6	7	8	9	10	11	12
Schedule 1:	0	1	12	48	84	96	99	100	100	100
Schedule 2:	15	38	63	81	91	95	97	99	99	99

Equilibrium numbers per recruit were computed for each age and intraannual time period by applying the appropriate set of natural and fishing mortality rates, using the standard exponential-decay model. The natural mortality rate was weighted by the durations of the relevant time periods for all computations involving partial years. The fishing mortality rate was partitioned by both fishery type and time period, and weighted by the appropriate selectivity factor. Equilibrium spawning per recruit was computed by applying the appropriate weight-at-age and maturity-at-age factors to equilibrium numbers at age in time period 1, and summing over age.

Once $F_{35\%}$ was calculated for a given management regime, it was again partitioned by fishery and time period, weighted by the appropriate selectivity factor, and applied to equilibrium numbers per recruit in each age group and time period according to the standard (i.e., Baranov's) catch equation, giving equilibrium catch per recruit in each age, fishery, and time period. Equilibrium catch per recruit in each age, fishery, and time period was then multiplied by the appropriate weight (to convert to biomass), and summed over all ages, fisheries, and time periods to compute total equilibrium yield per recruit under the given management regime.

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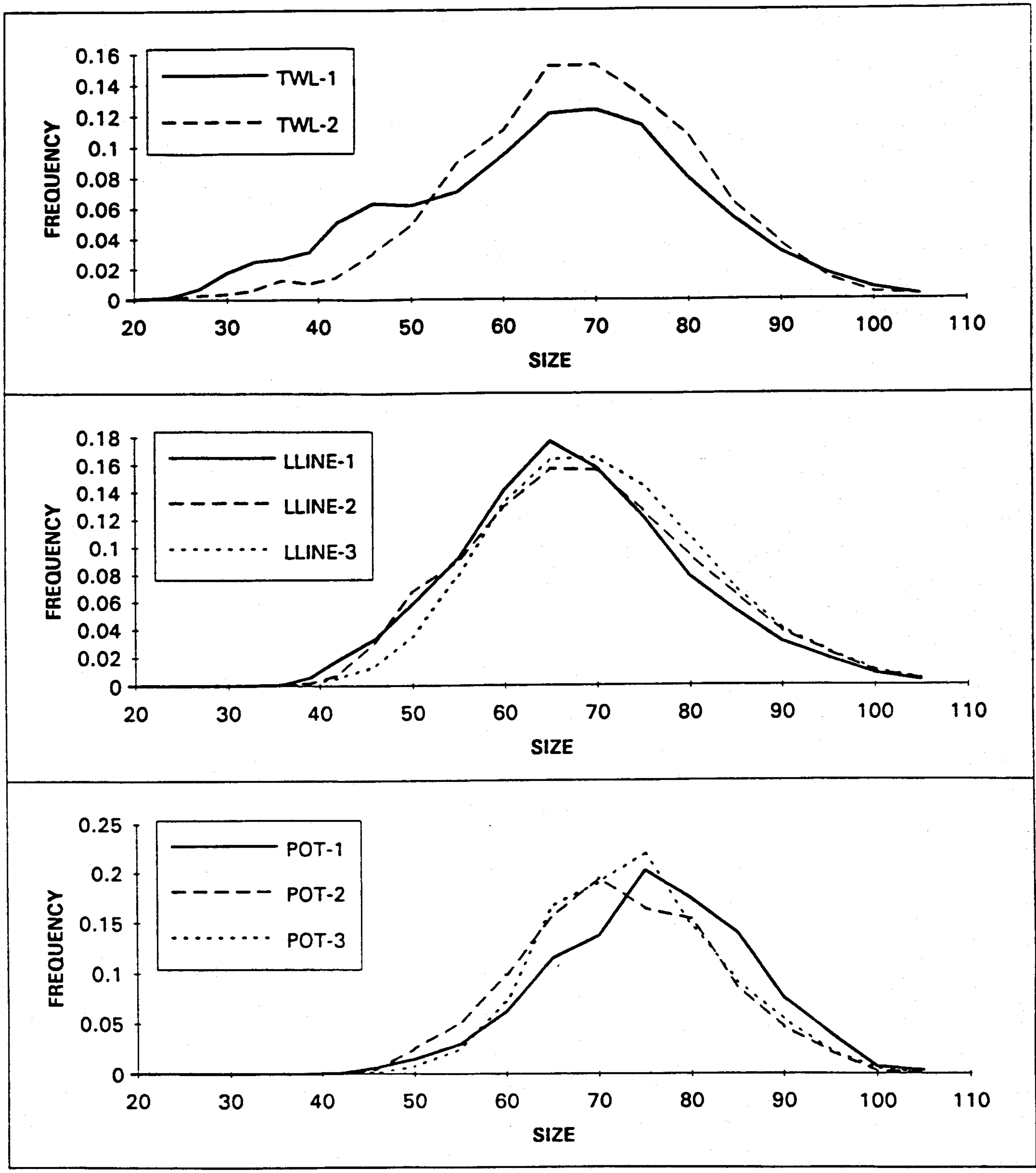
Figure 1.	Fishery size composition using combined data for 1990-1992. The data are stratified by gear type (trawl, longline, pot) and period (1=Jan-May, 2=June-Aug, 3=Sept-Dec). The data have been aggregated into 3 cm bins from 9 cm to 41 cm, 4 cm bins from 42 - 49 cm, and 5 cm bins from 50 cm to 109 cm.
Figure 2.	Example of the length at age matrix estimated in the Size Synthesis model. Here the estimated size distribution at each age is shown for the month of July and the number of fish at each age is decayed by a mortality of 0.35 per year.
Figure 3.	Time series of Pacific cod size composition in the Eastern Bering Sea bottom trawl survey.
Figure 4.	Time series of Pacific cod size composition in the January-May trawl fishery. The size bins are the same as in Figure 1. The time period designations on the right-hand side are Year.Period, where period 1 in January-May, 2=June-August, 3=September-December.
Figure 5.	Time series of Pacific cod size composition in the June-December trawl fishery. See Figure 4 for description.
Figure 6.	Time series of Pacific cod size composition in the longline fishery. See Figure 4 for description.
Figure 7.	Time series of Pacific cod size composition in the pot fishery. See Figure 4 for description.
Figure 8.	Time series of survey biomass. The circles indicate the biomass measured by the bottom trawl survey. The line indicates the model's estimate of biomass available to the survey in July.
Figure 9.	Time series of observed and estimated size composition for the bottom trawl survey in 1979-1992. The size bin definitions are as in Figure 1. The observed size composition is indicated by the dotted line, the model's estimate of size composition is the solid line.
Figure 10.	Time series of observed and estimated survey size composition for 1988-1992. See Figure 9 for description.
Figure 11.	Time series of observed and estimated trawl fishery size composition for 1990-1992. See Figure 9 for description.
Figure 12.	Time series of observed and estimated longline fishery size composition for 1990-1992. See Figure 9 for description.
Figure 13.	Time series of observed and estimated pot fishery size composition for 1990-1992. See Figure 9 for description.

Figure 14. Estimated population biomass for ages 3 and older in January and June of each year. In early years, growth dominated and biomass increased within the year. In later years mortality dominated. The time series of recruitment is shown as numbers at age 3.

Figure 15. Estimated size-specific selectivity for each fishery during 1990-1992 and for the bottom trawl survey.

Figure 16. Estimated mean age-specific selectivity for each fishery in 1990. Values were estimated by combining the estimated size-specific selectivities with the estimated frequency distribution of size at age at the midpoint of the season.



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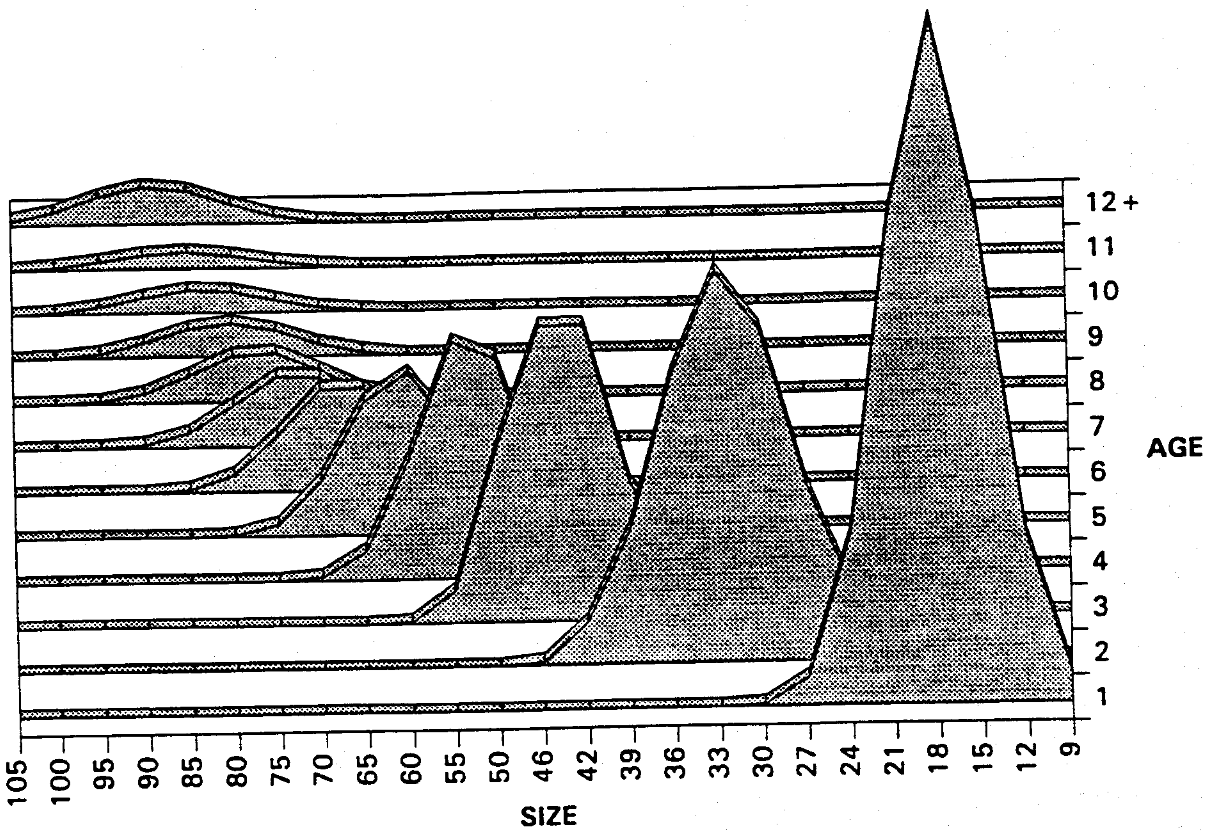

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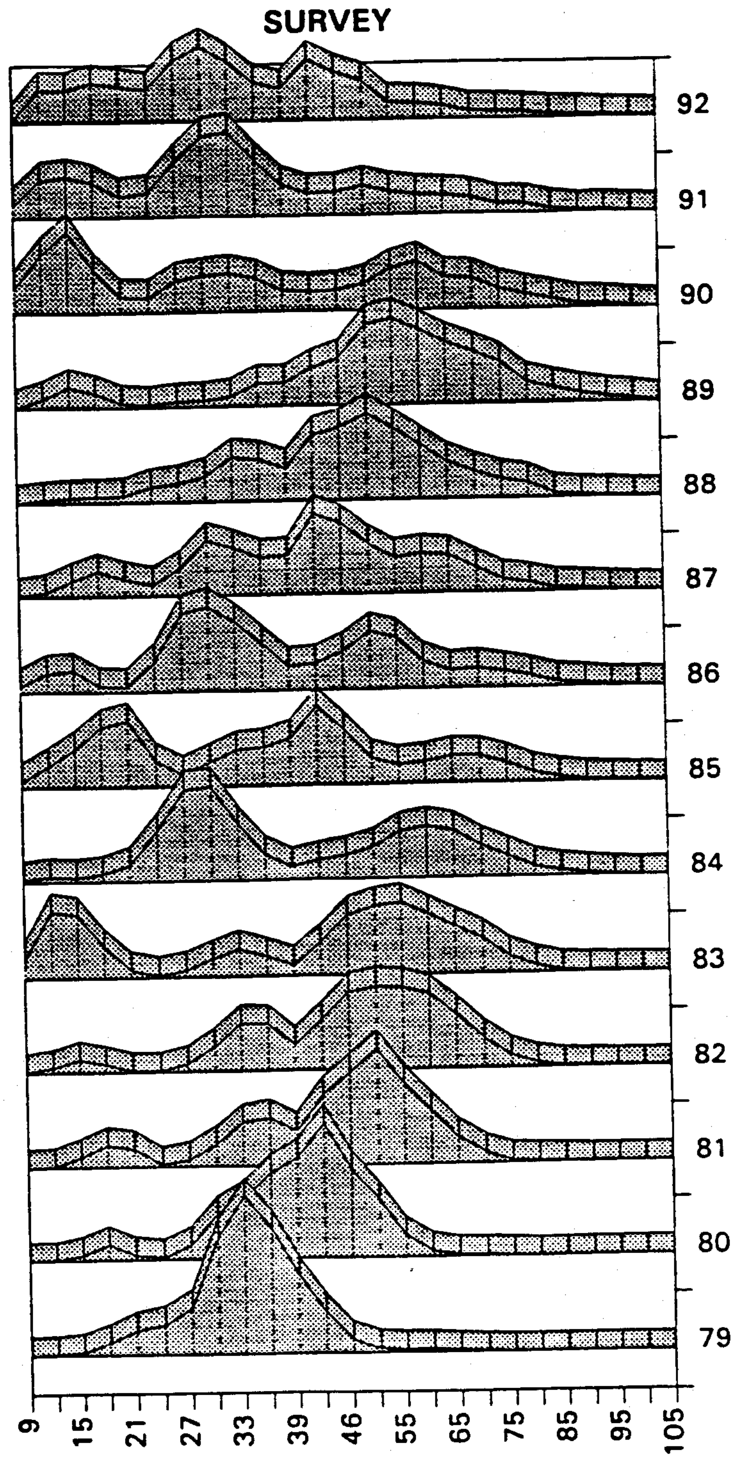


Figure 3. Time series of Pacific cod size composition in the Eastern Bering Sea bottom trawl survey.

JANUARY-MAY TRAWL

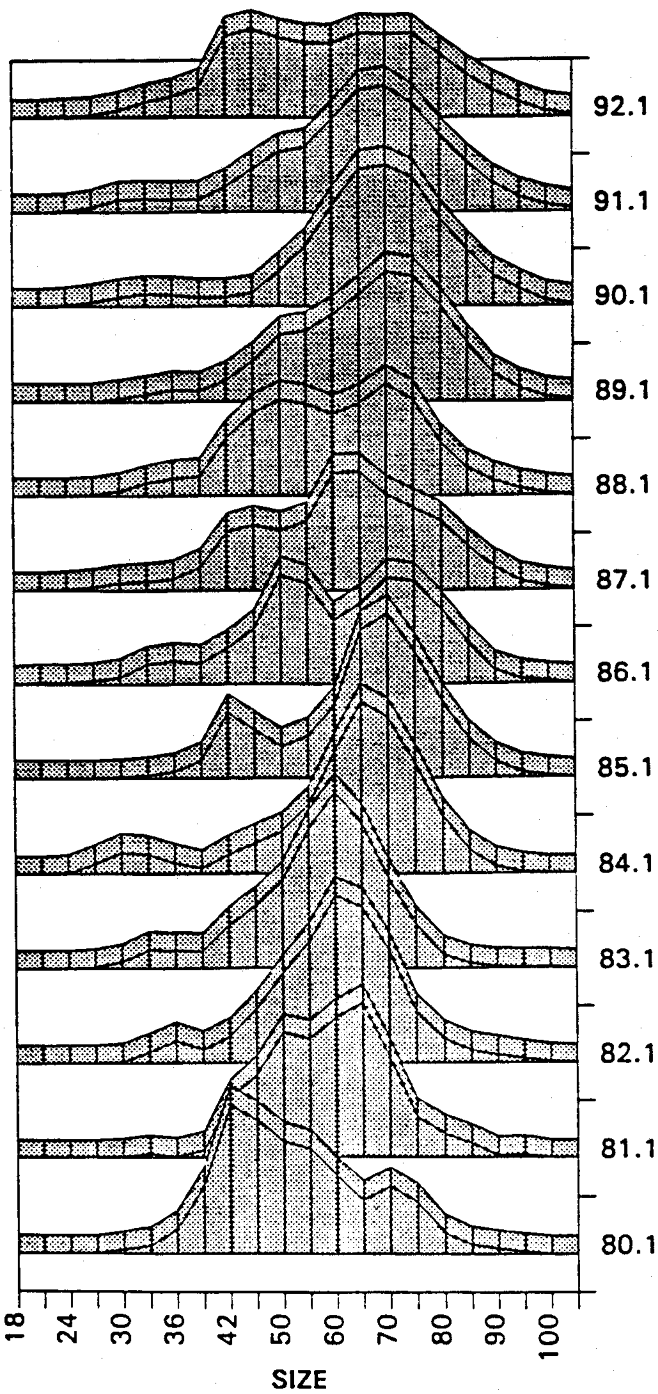


Figure 4. Time series of Pacific cod size composition in the January-May trawl fishery. The size bins are the same as in Figure 1. The time period designations on the right-hand side are Year.Period, where period 1 in January-May, 2=June-August, 3=September-December.

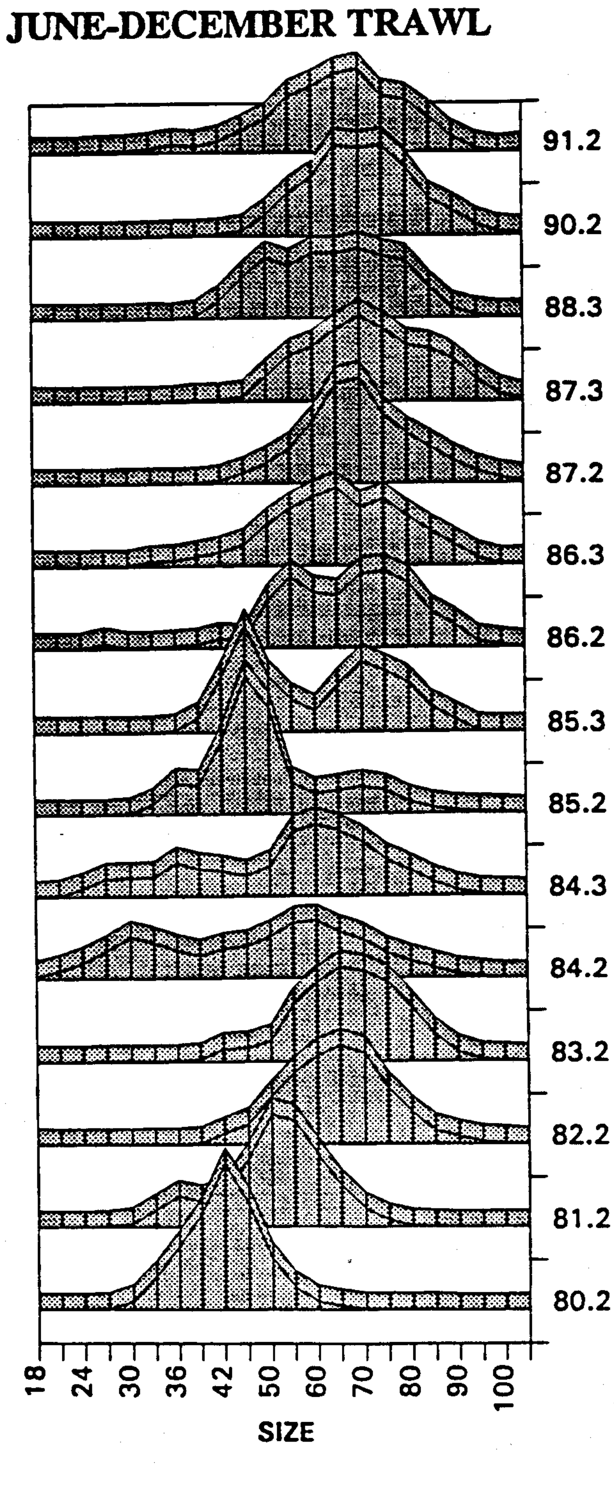


Figure 5. Time series of Pacific cod size composition in the June-December trawl fishery. See Figure 4 for description.

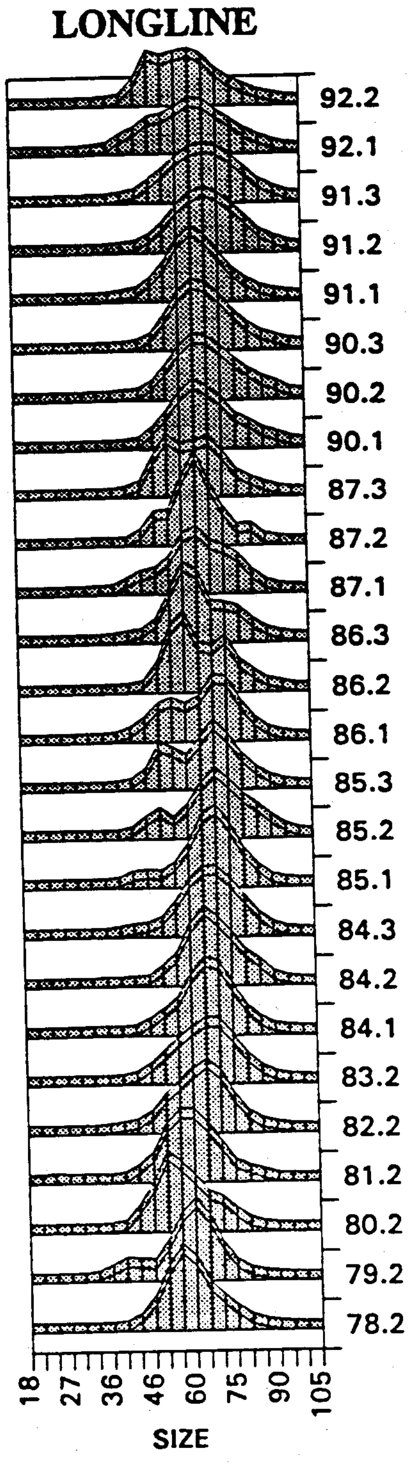


Figure 6. Time series of Pacific cod size composition in the longline fishery. See Figure 4 for description.

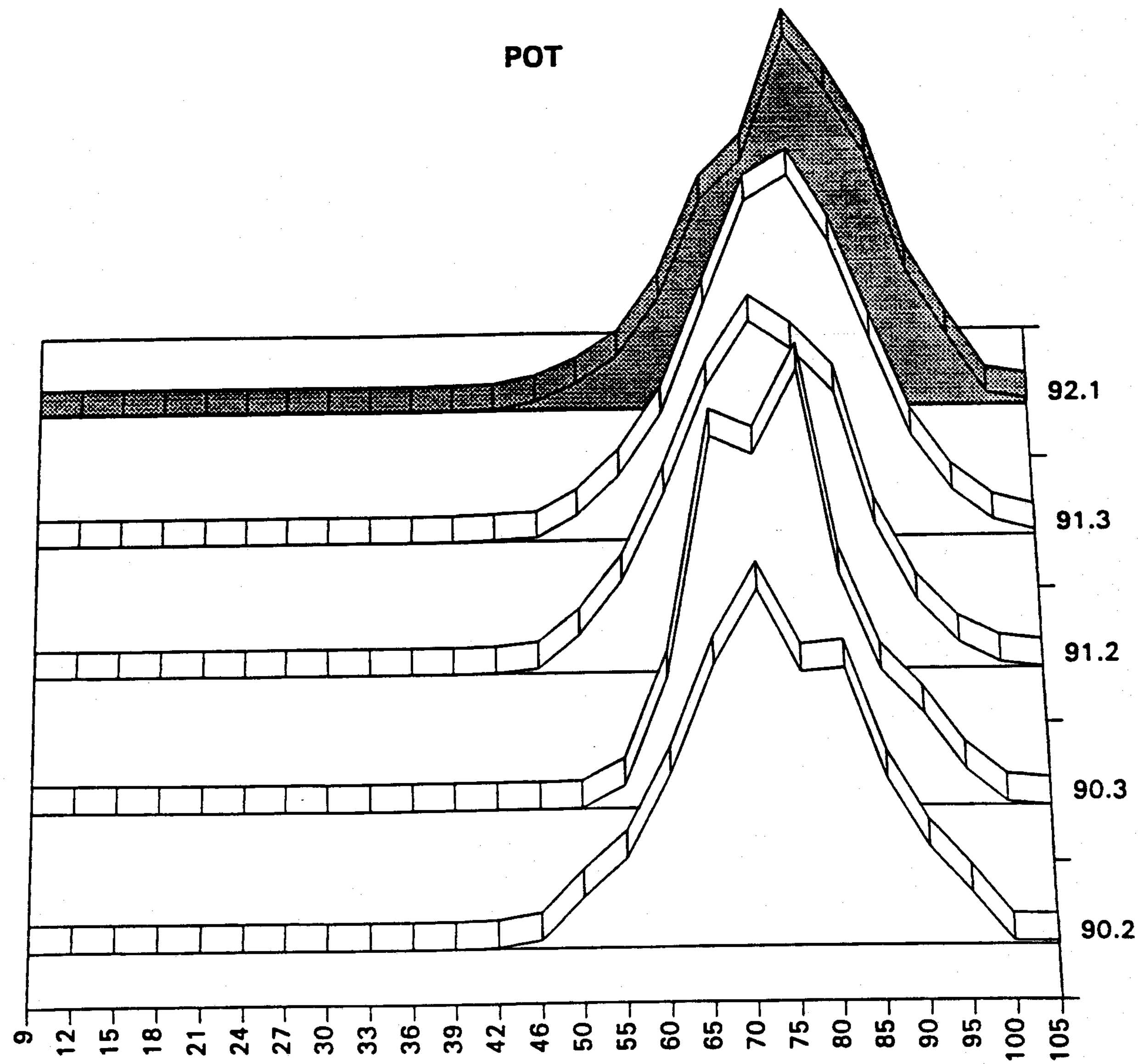
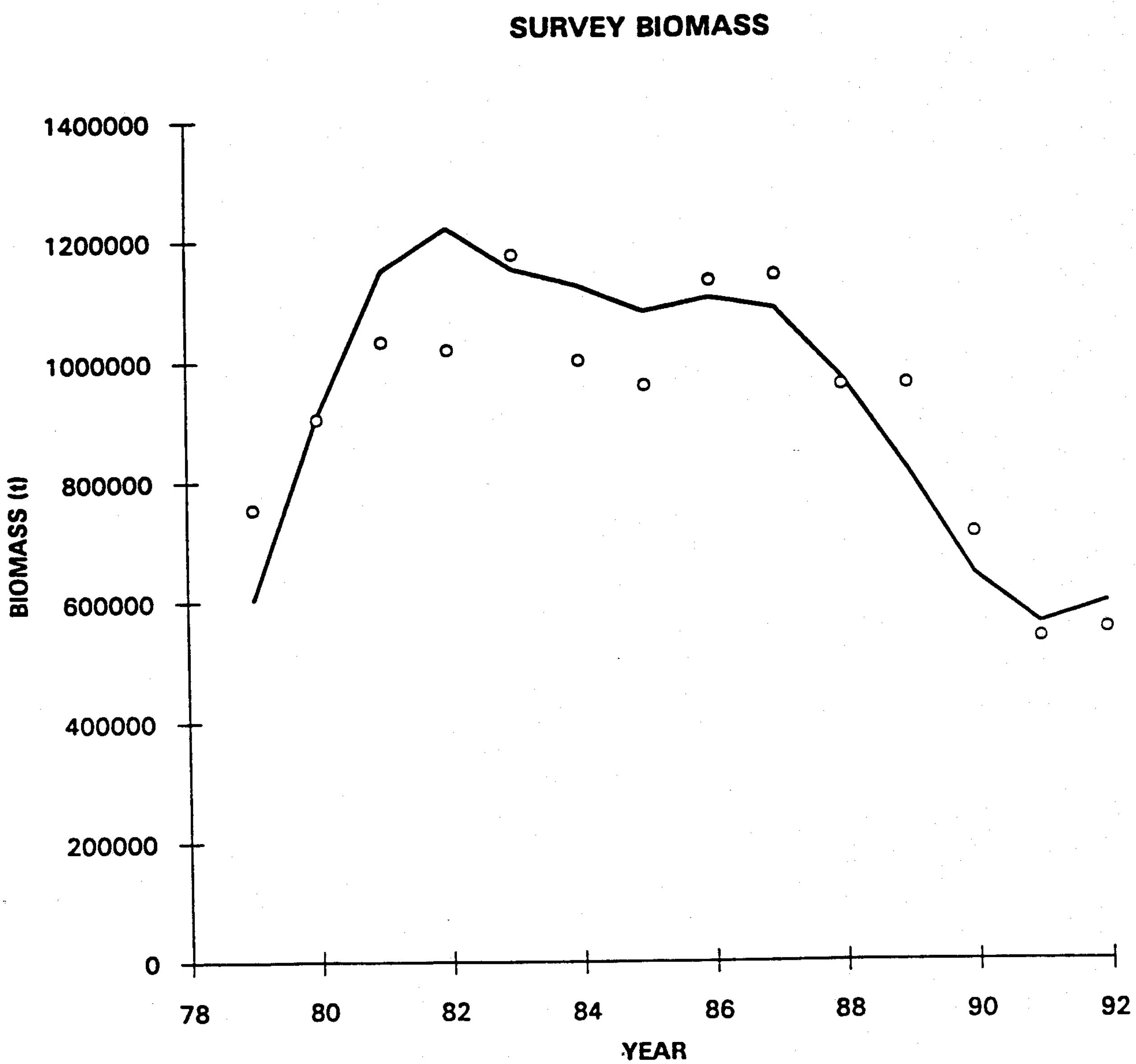


Figure 7. Time series of Pacific cod size composition in the pot fishery. See Figure 4 for description.



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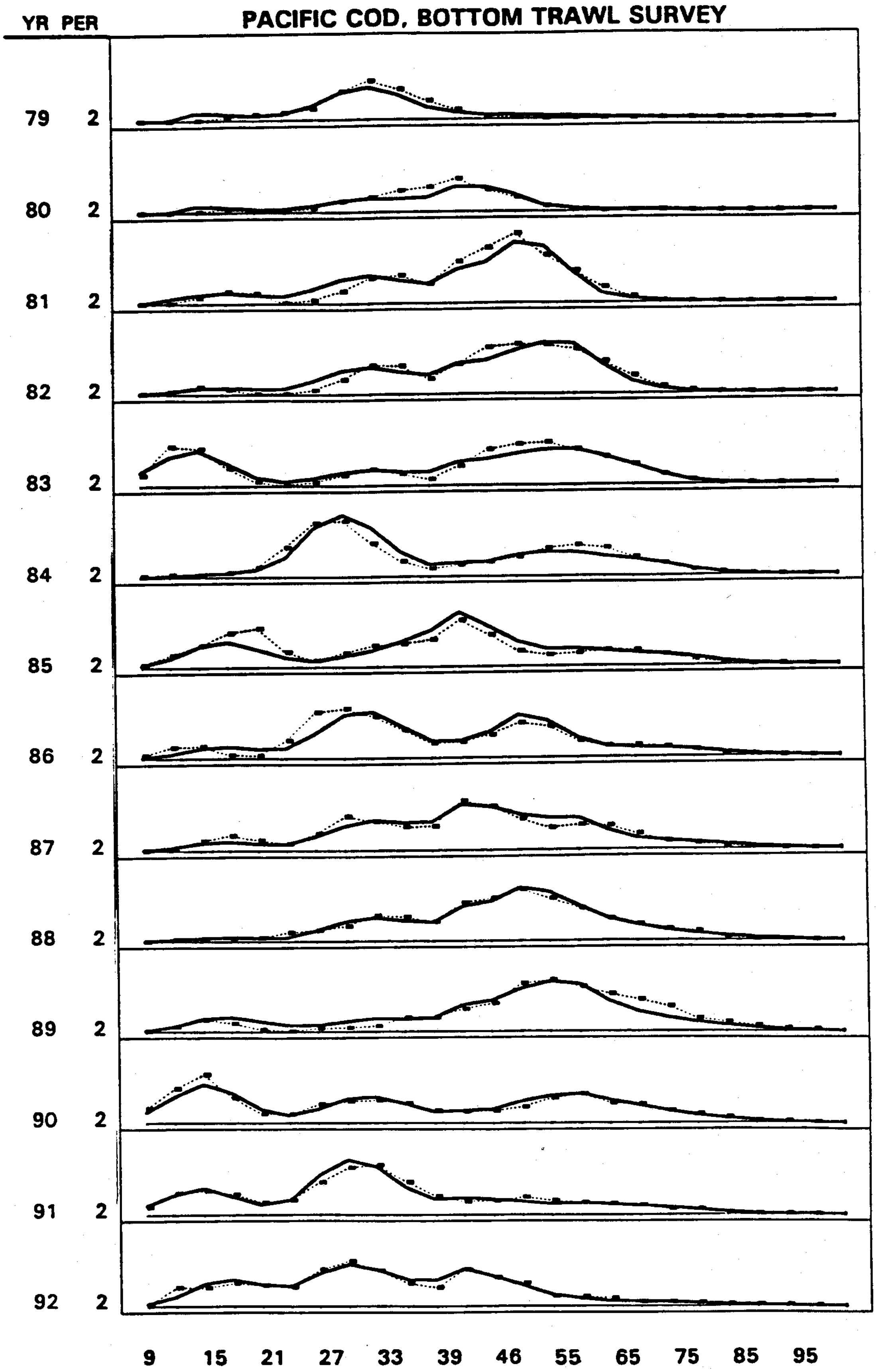

Figure 9. Time series of observed and estimated size composition for the bottom trawl survey in 1979-1992. The size bin definitions are as in Figure 1. The observed size composition is indicated by the dotted line, the model's estimate of size composition is the solid line.

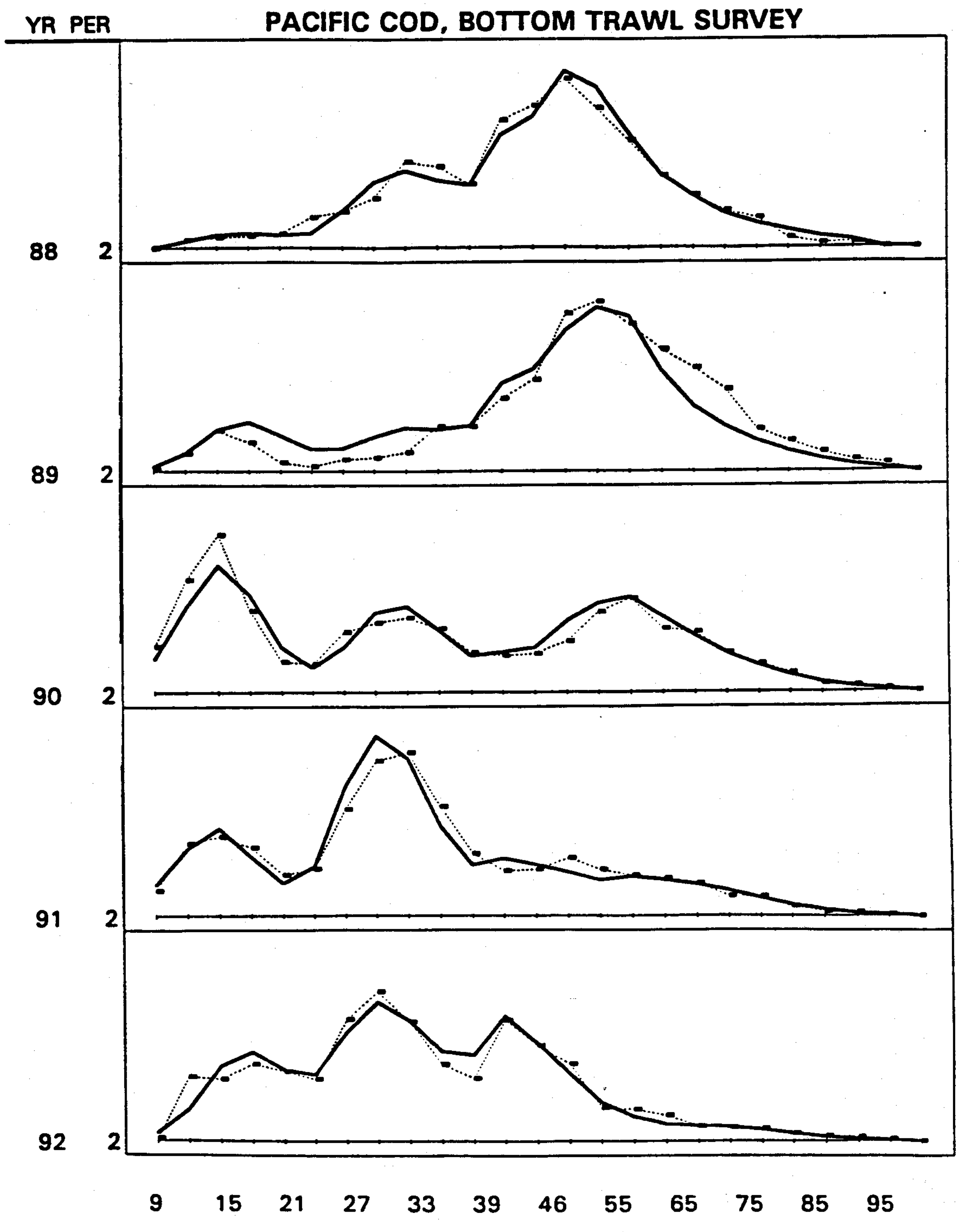

Figure 10. Time series of observed and estimated survey size composition for 1988-1992. See Figure 9 for description.

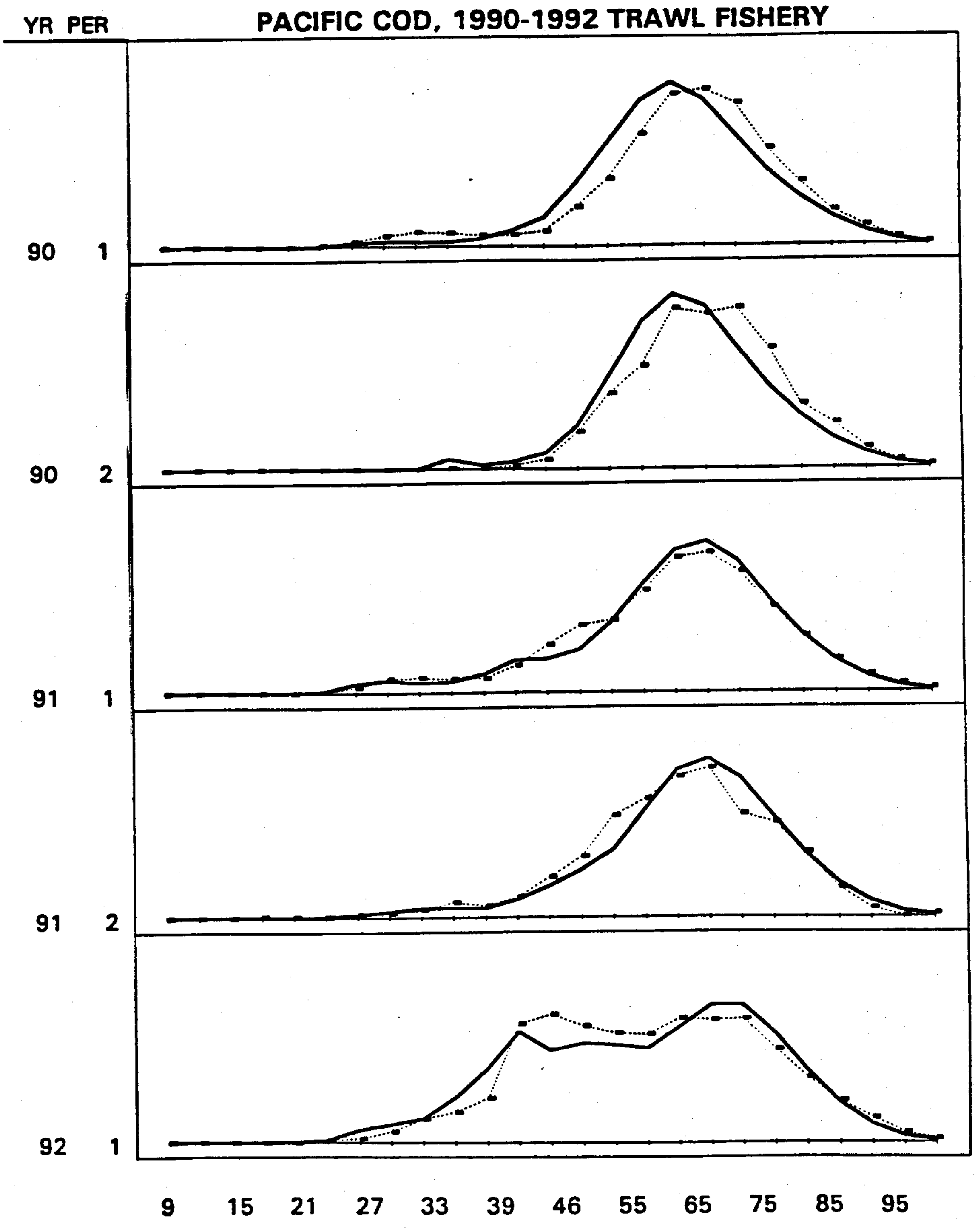

Figure 11. Time series of observed and estimated trawl fishery size composition for 1990-1992. See Figure 9 for description.

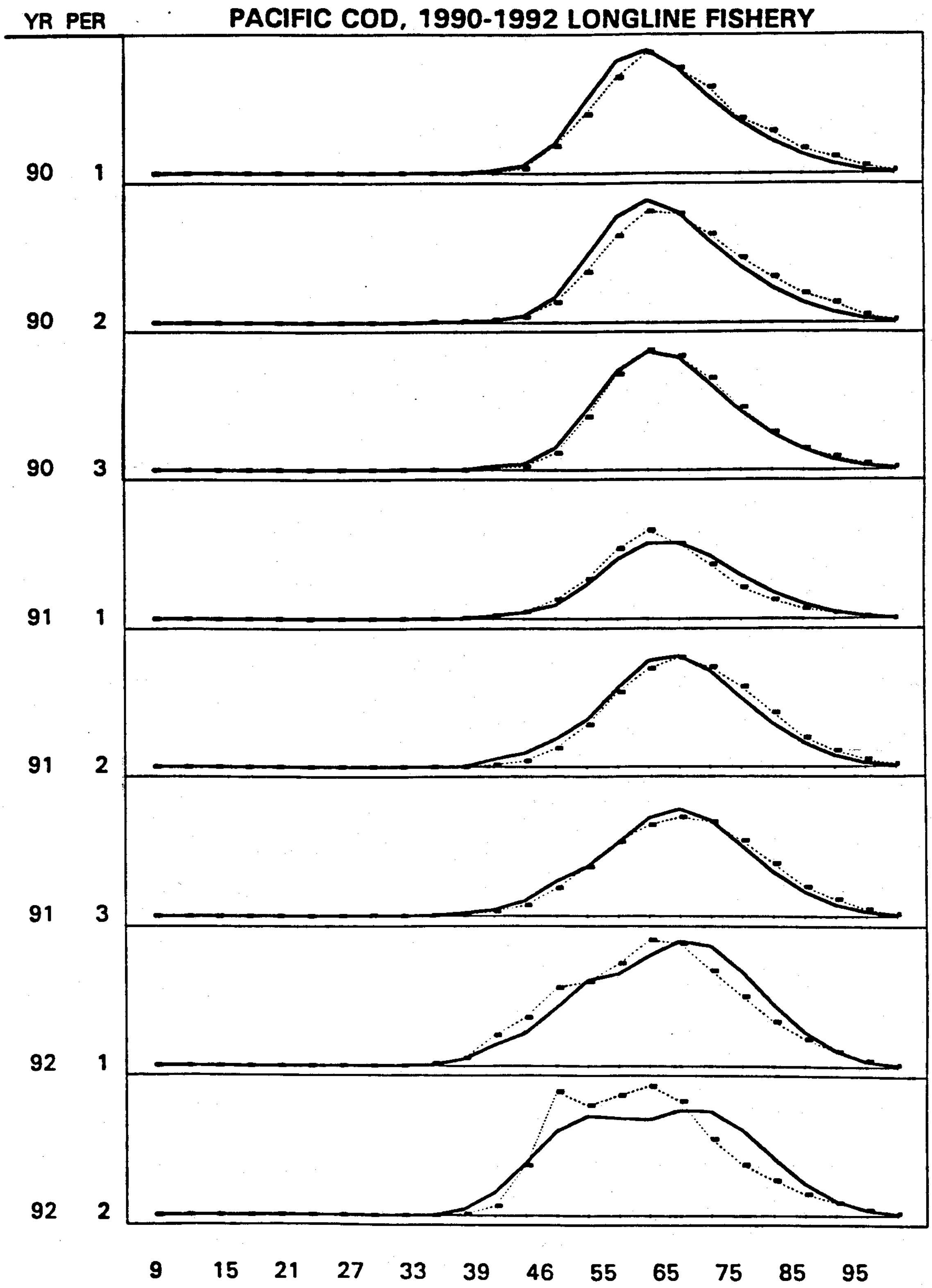

Figure 12. Time series of observed and estimated longline fishery size composition for 1990-1992. See Figure 9 for description.

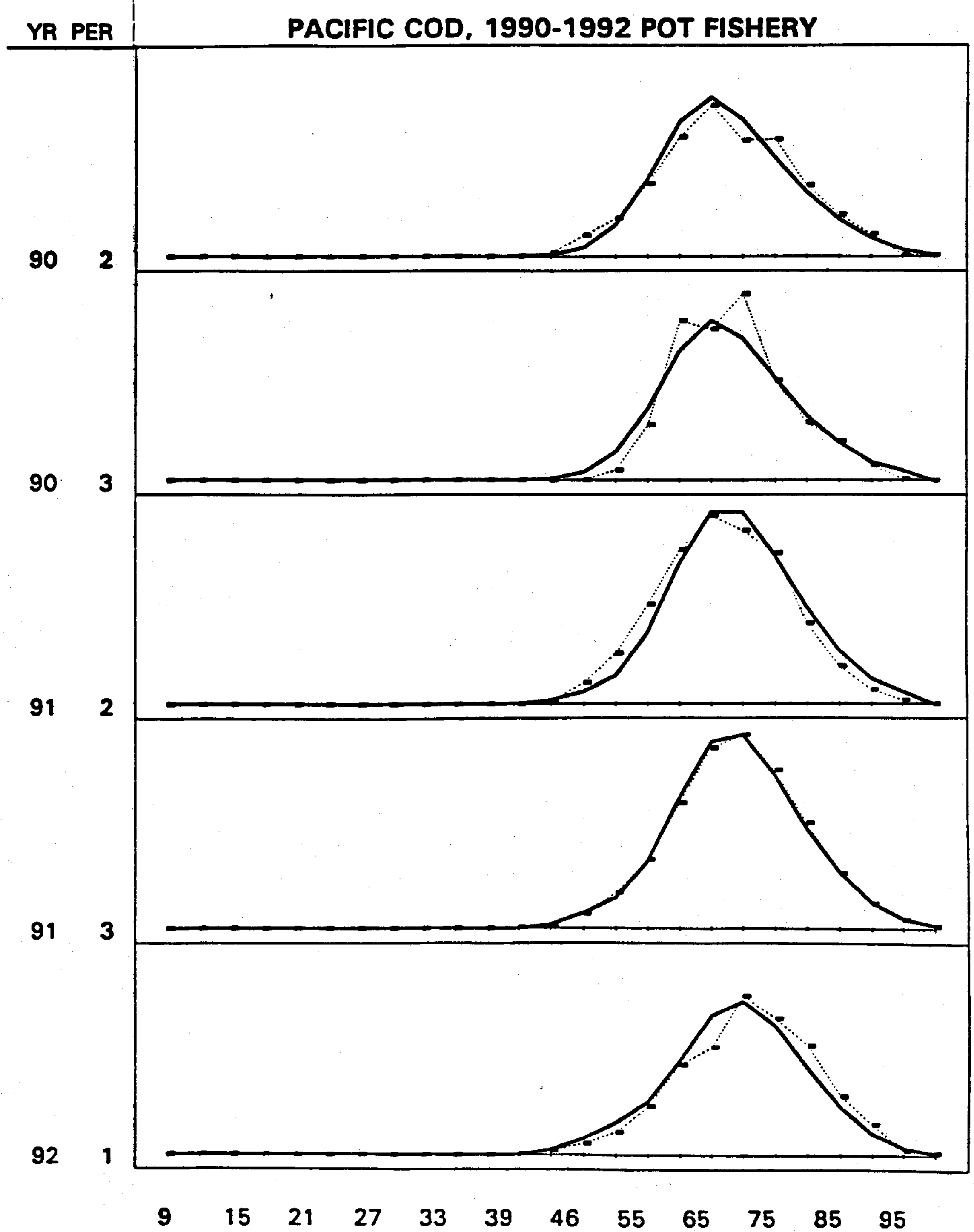

Figure 13. Time series of observed and estimated pot fishery size composition for 1990-1992. See Figure 9 for description.

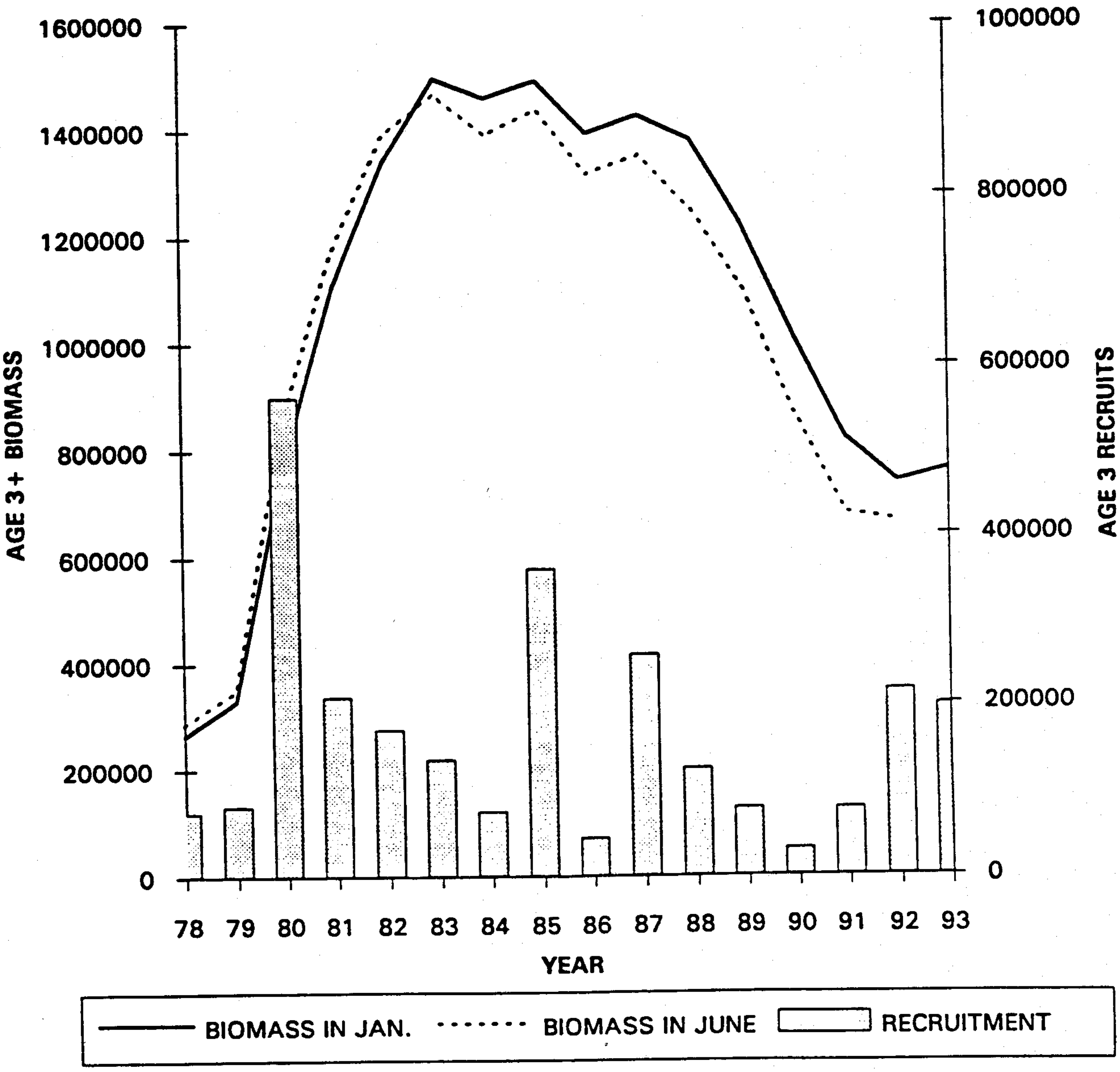

Figure 14. Estimated population biomass for ages 3 and older in January and June of each year. In early years, growth dominated and biomass increased within the year. In later years mortality dominated. The time series of recruitment is shown as numbers at age 3.

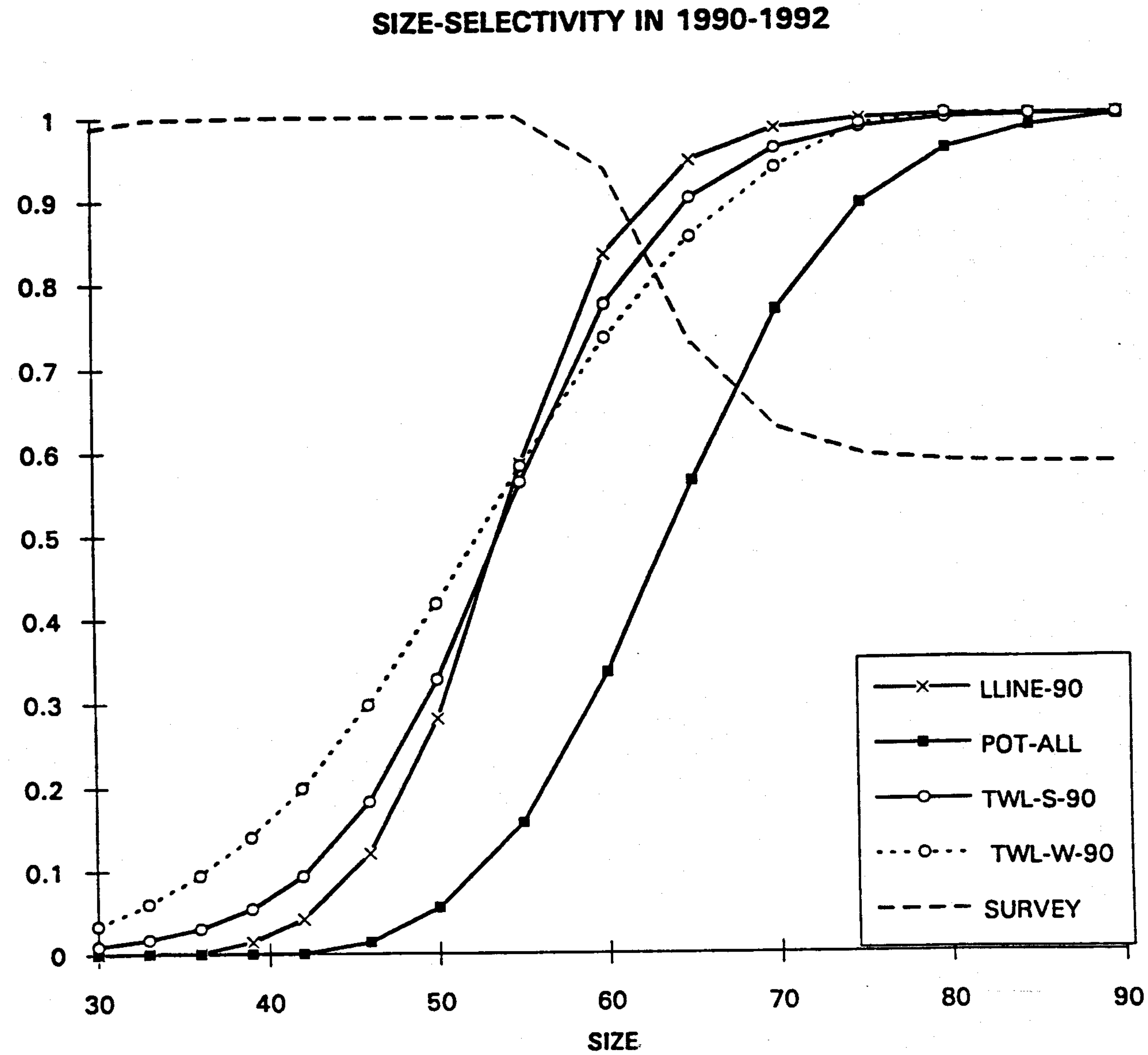

Figure 15. Estimated size-specific selectivity for each fishery during 1990-1992 and for the bottom trawl survey.

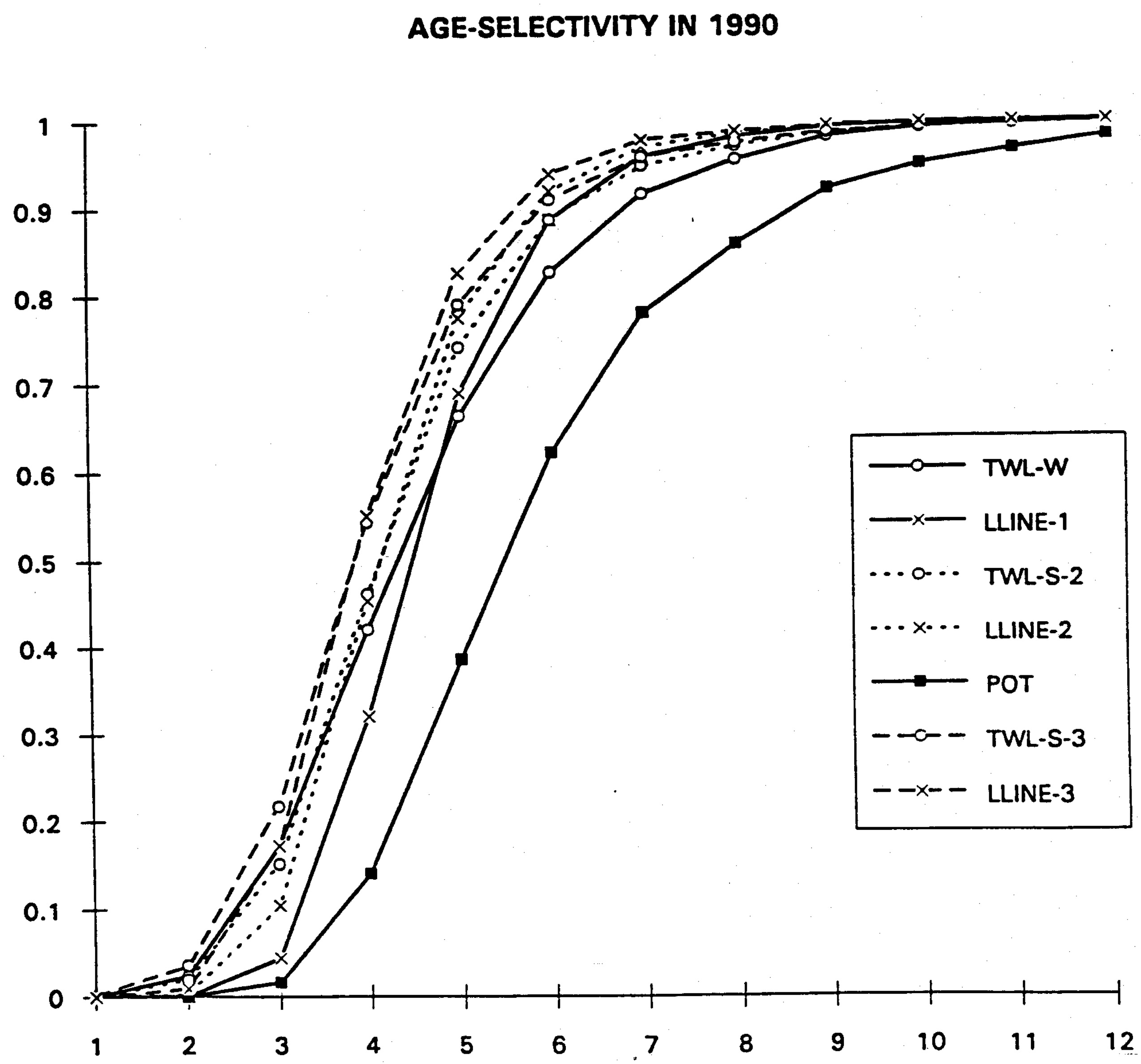

Figure 16. Estimated mean age-specific selectivity for each fishery in 1990. Values were estimated by combining the estimated size-specific selectivities with the estimated frequency distribution of size at age at the midpoint of the season.

APPENDIX F

IMPACTS OF TRAWLING ON THE SEABED AND BENTHIC COMMUNITY

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Introduction

In addition to its impacts on target species, fishing can also have impacts on non-target species and the seabed itself. Trawl gear, in particular, has attracted considerable attention in terms of its potential impact on non-target species and the seabed. Most of these studies have been conducted in the North Sea. Not only is trawl effort especially high in the North Sea, but concern there over the use of trawl gear has a history dating back several centuries. The following record from Parliament dates from the 14th century (de Groot 1984; note that the ancient term for trawl is "wondyrchoun"):

> "Your said Commons pray that whereas in divers places of your said realm in creeks and havens of the sea, where before these times good and plentiful fishing was wont to be, to the great profit of the realm, which is partly destroyed and made valueless for a long time to come by some fishermen who have during the past seven years by a new craftily contrived kind of instrument, which among themselves is called Wondyrchoun, made in the form of a drag for oysters, which is of unusual length: To which instrument is attached a net of so small a mesh that no kind of fish, however small, that enters it can pass out, but is forced to remain within it and be taken. And besides this, the great long iron of the Wondyrchoun presses so hard on the ground when fishing that it destroys the living slime and the plants growing on the bottom under the water, and also the spat of oysters, mussels, and of other fish, by which the large fish are accustomed to live and be nourished."

Perhaps prophetically, the official response to the above petition was the appointment of a committee to study the matter (de Groot 1984).

In terms of scientific investigations, the first research seems to have been a study dealing with the effects of the North Sea plaice fishery in 1938 (Graham 1955). Since then, a number of other scientific studies have been conducted. Although many of these focused on beam trawls, the results have been interpreted as being equally applicable to other types of trawl gear (de Groot 1984, Jones 1992). Areas of potential impact that have been investigated include physical impacts on the seabed (plowing), sediment resuspension, destruction of nontarget benthos, long-term impacts on the structure of the benthic community, change in forage availability, and grounds preemption. The information available for each of these areas is summarized below.

Physical Impacts on the Seabed

Depth, duration, and frequency of trawl tracks have all been measured by a number of studies. In general, each of these impacts depends on the weight of the gear on the seabed, towing speed, substrate type, and strengths of tides and currents (Jones 1992). Depth of penetration is typically found to fall within the 1 cm - 10 cm range. For example, de Groot (1984) found that beamtrawl tickler chains penetrated up to 1 cm in sandy substrate and 3 cm in mud, ICES (1988) found that trawl doors penetrated up to 5 cm in sand and 10 cm in mud, and Bergman and Hup (1992) found that beamtrawl shoes penetrated up to 6 cm in hard sand. At the extreme, Jones (1992) noted in a review article that trawl door penetration up to 30 cm had been observed in at least one study. Since the substrate in the eastern Bering Sea is mostly of the hard sand variety, such extreme impacts should be unlikely.

Temporal duration of trawl tracks can vary greatly. Jones' (1992) review showed an upper limit of five years for the duration of tracks in sandy mud, whereas the tracks observed in hard sand by Bergman and

Hup (1992) lasted for about 16 hours, and the tracks observed in hard sand by de Groot (1984) had a lifespan of only 75 minutes. Again, the fact that most of the substrate in the eastern Bering Sea is of the hard sand variety indicates that track duration should be minimal.

In heavily fished areas, a patch of ground might be impacted by trawl gear several times during a year. Churchill (1989) found an average of 20 tracks per 100 m^2 on the southern New England continental shelf. Rauck (1985, cited in ICES 1988 and Bergman and Hup 1992) calculated that each m^2 in some parts of the North Sea was trawled an average of 3-5 times per year, while Welleman (1989, cited in Bergman and Hup 1992) calculated a rate of 7 times per year for the same locations (but different year). However, it should be remembered that trawl effort in the eastern Bering Sea is generally considered to be much less than in New England or the North Sea.

Sediment Resuspension

Churchill (1989) found that trawling can be a primary source of suspended sediment over the outer continental shelf. Possible adverse impacts resulting from increased suspension of sediments include a reduction of light levels on the seabed, smothering of benthos following resettlement, creation of anaerobic conditions near the seabed, and reintroduction of toxins that may have settled out of the water column (ICES 1988, Jones 1992). It does not appear that organic material resuspended as a result of fishing activity improves nutrient availability to filter feeders (Anderson and Meyer 1986).

Adverse effects from resuspension of sediments are probably minimal in areas with significant current or tidal transport, since organisms in these areas are presumably adapted to such events (ICES 1988, Jones 1992). In the deep ocean, however, the effects would likely be greater (Jones 1992).

Destruction of Benthos

It is generally believed that trawling reduces the biomass of benthic organisms. Because crab bycatch is considered elsewhere in this document (Section 2.2.6) the discussion here will concentrate on other species, most of which are not of direct commercial importance.

Trawl-induced mortality stems both from damage inflicted by the gear itself as it passes over the seabed and from capture- and handling-related mortality of organisms taken in the net. In terms of the former, the abundance of benthic organisms may be decreased by 40% or more within the trawl tracks immediately after trawling (ICES 1988, Bergman and Hup 1992). However, some of this decrease may be due simply to dislocation, as opposed to destruction (Rumohr and Krost 1991). In either case, at least some recolonization from outside the tracks would be expected shortly thereafter. In one study, most epibenthic organisms regained their original density after about 24 hours (Rumohr and Krost 1991).

Capture- and handling-related mortality can also have substantial impacts on organisms that actually make it into the net. In one study, molluscs and crabs showed at least 40% mortality due to capture and handling, starfish 70-80%, and whelks and hermit crabs approximately 100% (Fonds 1991).

The amount of trawl-induced mortality is a function of species morphology, size, and depth of occurrence in the substrate. For example, in a study conducted in Kiel Bay (Baltic Sea), Rumohr and Krost (1991) found that thin-shelled bivalves such as *Syndosmya (Abra) alba*, *Mya* sp., and *Macoma calcarea*, as well as the starfish *Asterias rubens* were substantially damaged by the passage of trawl gear, while thick-shelled bivalves such as *Astarte borealis* and *Corbula gibba* were fairly resistant, and impacts on *Arctica islandica*, *Macoma baltica*, and *Macoma calcarea* were related to body size. Large specimens of *Arctica islandica* were more affected than smaller specimens due to the unfavorable relationship between shell surface area and shell thickness. The size distribution of *A. islandica* in heavily trawled areas showed reductions in the upper size class in these areas, which Rumohr and Krost (1991) viewed as corroboration of their finding that trawl-induced mortality was size specific.

Community Structure

Some writers have suggested that trawling can lead to long-term shifts in the species composition of the benthic community. Most studies seem to conclude that trawling tends to cause an increase in the relative abundance of fast-growing and fast-reproducing species such as polychaetes at the expense of slow-growing and slow-reproducing species such as molluscs and crustaceans (Reise 1982, Riesen and Reise 1982, de Groot 1984, Pearson et al. 1985, ICES 1988). However, it is difficult to demonstrate rigorously that trawling was actually the cause of the species shifts observed in those studies (Jones 1992). Graham (1955) concluded that there was no clear difference between the benthic communities of trawled and untrawled areas in the North Sea. Likewise, a Dutch study was unable to draw a clear causal relationship between differences in species composition and beam trawling (Bergman 1991).

Forage Availability

Although most studies indicate that trawling at least carries the potential to damage benthic organisms (see "Destruction of Benthos" section), this does not necessarily translate into a decrease in forage availability for those species that feed upon benthic prey. For example, Graham (1955) concluded, "Damage to fish food species trawled over in the main area of the North Sea plaice, cannot be serious...." Other studies (reviewed by ICES 1988 and Jones 1992) have suggested that the effect was actually (or at least could be) positive.

Arntz and Weber (1970, cited in de Groot 1984, Rumohr and Krost 1991, Bergman and Hup 1992, and Jones 1992) observed that the stomach contents of cod in Kiel Bay (Baltic Sea) began to contain an extraordinary amount of the bivalve *Arctica (Cyprina) islandica* once trawling commenced in the area. Their conclusion was that the fish were feeding on animals crushed by the trawl doors. Brey et al. (1990) calculated the annual production of *A. islandica* in Kiel Bay and concluded that it could support 40% of the annual cod production.

In another study, Caddy (1973) found that fish and crabs were attracted to the trawl path within 1 hour after fishing and were observed in the tracks at densities up to 30 times greater than the densities observed outside the tracks.

Grounds Preemption

In areas which are trawled by vessels of greatly different horsepower, it is sometimes possible for the larger vessels to render the grounds untrawlable by the smaller vessels. De Groot (1984) described a complaint brought by small trawlers from Corsica, in which it was alleged that large trawlers were uncovering boulders buried in the seabed which then made the grounds inaccessible to the small trawlers. Bridger (1970) substantiated this complaint.

Conclusions

In conclusion, it is clear that trawling can impact both the seabed and the benthic community. The extent of these impacts depends on the weight of the gear, the towing speed, the nature of the bottom sediments, and the strengths of tides and currents. Bottom trawl doors leave scars on the seabed that can last for minutes, hours, or years. Trawls can damage benthic organisms, thereby causing changes in community species composition and population age structure, but perhaps also leading to an increase in the availability of forage for commercial species. Whether changes in community species composition would tend to come at the expense of commercially important species such as crab is difficult to determine. In any case, it is important to remember that the impacts described here become relevant only if any of the alternatives examined in this amendment result in a change in the *total amount* of trawling in an area, as opposed simply to a change in the amount of trawling for Pacific cod which is offset by an increase in the amount of trawling for other species in the same area.

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APPENDIX G

REVIEW OF THE EFFECT OF FISHING ON SPAWNING STOCKS

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Fishing on pre-spawning and spawning aggregations of fish has a long history. In Norway, the cod fishery in the Lofoten Islands has been fished commercially during the spawning period as far back as the middle ages. Likewise, herring have been fished on Norwegian coastal spawning banks for an equally long time. In general, herrings, cods, capelin, and some flatfish species are fished on the spawning grounds because of high catch rates and the higher economic value of roe bearing fish.

The question of the effects of fishing on spawning fish has been repeatedly raised for various stocks of fish. Most recently as part of an inquiry into the status of the northern cod stock off Labrador and Newfoundland, Canada (Harris 1990). Section 6.7.0 of the report addresses Fishing on Spawning Stocks and Groups. The entire section is reproduced here, since it succinctly summarizes the current knowledge and scientific thought on the effects of fishing on spawning stocks.

> During the course of the Panel's public hearings, a number of questions were raised regarding, - the impact of offshore fishing on spawning groups and aggregations and upon the spawning grounds themselves. The often passionate protestations left no doubt of the strong convictions held by many fishermen that fishing on spawning populations is "destructive" and is the largest contributor to the decline of the northern cod stock. Such convictions are often shared by fishermen everywhere and, since the questions put to the Panel are hardy perennials among fishermen, they bear some discussion.
>
> It is not inappropriate to note at the outset that many of the world's major fisheries are conducted just prior to or during times of spawning. These include capelin, herring, salmon and the flounder fisheries, as well as fisheries for most cod-like species. For most of these management strategies involve controlling the level of fishing to insure that an adequate spawning stock is maintained. If a spawner/recruitment correlation is clearly known then knowledge of that relationship is used to establish catch levels.
>
> However, when the available quota of a particular species can be taken throughout the year, fishermen tend to regulate their activities to times and locations that take advantage of fish aggregations, or of other behavioral characteristics of the target species; that respond to market demands; or that merely suit their own particular convenience. In the case of northern cod, inshore fishermen catch them when they congregate inshore on their feeding migration. If the situation were reversed and cod moved inshore to spawn and offshore to feed, it is certain that the inshore fishery would be a spawning fishery just, in fact, as is the capelin fishery. And, in a strict mathematical sense that would make no difference to the survival of the species. For, assuming a target fishing rate, it does not matter in terms of the spawner stock at what time of the year the harvest mortality is imposed. If other factors are not of concern, the goal of preserving the stock will be realized by maintaining a desired level of spawning population with the appropriate age structure within that population. The important fact is the number of fish that are killed, or rather the number that are spared, and not the date on which the killing occurs.
>
> There are, of course, good and valid fishing regulations which prohibit certain fisheries during the spawning period, but such regulations are frequently based on other important management goals. For example, fishing salmon on their spawning grounds is generally prohibited because such activity would disrupt or damage or perhaps destroy the spawning habitat. By the same token, for species whose eggs are deposited in bottom sediments or attached to plants or adhere to rocks, shells, etc., the prohibition of fishing in areas and/or with gear types that may alter or destroy the spawning habitat is desirable. In other cases, fishing during spawning periods may be prohibited because the general biological and physiological, and/or market condition of the fish at that time may produce a poor quality product providing lower yields or lower market values. On the other

hand, in the case of species like capelin, lumpish, or sturgeon, for example, the maximum value occurs during the spawning period because the valuable product is the roe. Even in the case of salmon, though they are not fished on the spawning grounds, it is frequently argued that better management is possible if the fish are taken when they congregate to enter the spawning streams since at that time fishing effort can be more effectively distributed proportional to spawning stock size. In fact, Newfoundland fishermen take salmon just prior to spawning, intercepting them as they approach the spawning rivers. **For cod there is no recorded evidence that fishing during spawning periods affects the spawning habitat in a negative manner or that fishing in other periods of the year will result in better survival of the spawned eggs. Thus, there is little if any substantiated evidence supporting the claim that fishing by trawls during the spawning season damages survival of the spawning products or that such removals are more damaging than taking fish during other periods of the year.**

Nevertheless, we cannot leave this subject without injecting a cautionary note. The state of our current knowledge is such that we cannot easily answer the question whether intense fishing on spawning cod populations disturbs either the mating behavior or the spawning success of the aggregate. Nor can we be sure that fishing on large spawning aggregates will not lead to localized depletions so that overfishing of particular spawning groups may lead directly, in the short term, to shortages of fish in particular inshore areas. The longer term impacts are, however, speculative because we are not sure of the year-to-year integrity of spawning aggregates or of the relative contribution such spawning groups may have to the northern cod recruitment. That is to say, we cannot give anything like a definitive answer until we know a great deal more about the nature of the spawning subgroups, their aggregational patterns from year to year, the manner in which recruitment to such groups is affected, and the nature of their feeding and spawning migrations. **Once again, further study is indicated and, in light of the strongly held public perceptions, should be treated as a matter of some urgency.**

The preceding quotation is from: Harris, L. 1990. Final Report, Independent review of the state of the northern cod stock. Dept. Fish. Ocean., Ottawa. 154 pp.

In summary there is no clear deleterious effect of fishing on spawning concentrations of cod or other marine fishes. However, as the Canadian northern cod study points out, there may be subtle effects that cannot be readily detected. Never-the-less, the history of fisheries does not indicate that fishing during the spawning period only has led to any measurable biological changes or cause reduced survival of prodigy.

In some Atlantic cod fisheries the fishery is closed during the period of peak spawning, and fishing is prohibited during the time of day that active spawning takes place, usually at night. This may help to minimize behavioral effects from fishing, but there are no substantiating data. Pacific cod produce demersal eggs that are deposited on bottom. Prohibition of on-bottom trawling may protect developing eggs. It is impossible to say what various measures employed to regulate fisheries on spawning Atlantic cod would have on Pacific cod. The location of spawning grounds off Alaska is only generally known. Specific spawning behavior, the time of peak spawning, and the extent of interannual variation in timing of peak spawning are unknown.

APPENDIX H

SOME POSSIBLE EFFECTS OF INCREASED EARLY-SEASON EFFORT ON EQUILIBRIUM CATCH AND STOCK SIZE

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Introduction

Most fishery models assume that fishing effort is distributed evenly over the course of the harvest year. In practice, however, fishing effort is often concentrated during the early months. Some possible effects of such a pattern of effort distribution can be examined by means of a simple model that employs the following assumptions:

(A) Recruitment occurs instantaneously at the start of the harvest year.

(B) With the exception of the recruitment event, stock dynamics are continuous, with a constant natural mortality rate.

(C) The stock is managed on the basis of a fixed annual survival rate, applied to stock numbers.

(D) Two management options exist regarding the distribution of fishing effort: (a) effort is distributed uniformly over the harvest year, and (b) effort is distributed uniformly within a time period of length p ($0<p<1$) that begins at the start of the harvest year.

(E) Spawning takes place annually at time q, where q is expressed as a fraction of the harvest year.

(F) Recruitment is governed by the Cushing stock-recruitment relationship, with spawning stock measured in terms of numbers.

Management Option (a)

Under Assumptions (A) and (B) and Management Option (a), equilibrium recruitment R can be described by the following equation:

$$R = N_0\left(1 - e^{-F-M}\right), \tag{H1}$$

where N_0 = equilibrium stock size at time 0 (the start of the harvest year), F = instantaneous rate of fishing mortality under Management Option (a), and M = instantaneous rate of natural mortality.

However, by Assumption (F), equilibrium recruitment must also conform to

$$R = a\left(N_q\right)^b, \tag{H2}$$

where a and b are parameters ($0<b<1$) and N_q = equilibrium stock size at the time of spawning.

Equilibrium spawning stock size can in turn be written as

$$N_q = N_0 e^{-(F+M)q}. \tag{H3}$$

Substituting Equation (H3) into Equation (H2) and solving the resulting expression simultaneously with Equation (H1) gives the following expression for equilibrium stock size at the start of the year:

$$N_0 = \left(\frac{ae^{-(F+M)qb}}{1-e^{-F-M}}\right)^{\frac{1}{1-b}}. \qquad \text{(H4)}$$

Equilibrium catch (in numbers) can be determined from Equation (H4) by using Baranov's catch equation.

Management Option (b)

Note that Assumptions (D) and (E) allow the concentrated fishing season under Management Option (b) to end either before or after the time of spawning; that is, p can be greater than q (Case I) or less than q (Case II). The equations describing equilibrium catch and stock size will in general depend on which case is being considered. An exception to this is Baranov's catch equation, which, because it does not involve q, is modified in a way that does not depend on whether Case I or II is being considered. Because of Assumption (C), the fishing mortality rate under Management Option (b) is always F/p, and Baranov's catch equation is modified to read

$$\hat{C} = \frac{\hat{N}_0(F/p)(1-e^{-F-Mp})}{(F/p)+M}, \qquad \text{(H5)}$$

where C = catch (in numbers), and the carat symbol is used to designate stock performances under Management Option (b).

Case I: $p>q$

When $p>q$ under Management Option (b), equilibrium spawning stock size can be written as

$$\hat{N}_q = \hat{N}_0 e^{-[(F/p)+M]q}. \qquad \text{(H6)}$$

Equation (H6) can be used in the same manner as Equation (H3) to derive equilibrium stock size at the start of the year under Management Option (b), giving:

$$\hat{N}_0 = \left(\frac{ae^{-[(F/p)+M]qb}}{1-e^{-F-M}}\right)^{\frac{1}{1-b}}. \qquad \text{(H7)}$$

Conveniently, the ratio between Equations (H7) and (H4) can be expressed as a simple function of b, F, p, and q:

$$\frac{\hat{N}_0}{N_0} = e^{-qF\left(\frac{1-p}{p}\right)\left(\frac{b}{1-b}\right)}. \tag{H8}$$

The ratio described by Equation (H8) is always less than 1.0, implying that equilibrium stock size (and therefore equilbrium recruitment) under Management Option (b) is always less than under Management Option (a).

The ratio between equilibrium catch under Management Option (b) and equilibrium catch under Management Option (a) is given by

$$\frac{\hat{C}}{C} = \left(\frac{F+M}{F+Mp}\right)\left(\frac{1-e^{-F-Mp}}{1-e^{-F-M}}\right)e^{-qF\left(\frac{1-p}{p}\right)\left(\frac{b}{1-b}\right)}. \tag{H9}$$

Unlike the ratio of equilibrium stock sizes, the catch ratio described by Equation (H9) can be greater than or less than 1.0, depending on the values of the involved parameters. The "breakeven" value of q (q^*, the value which sets Equation (H9) equal to 1.0) is given by

$$q^* = \left(\frac{1}{F}\right)\left(\frac{1-b}{b}\right)\left(\frac{p}{1-p}\right)\ln\left[\left(\frac{F+M}{F+Mp}\right)\left(\frac{1-e^{-F-Mp}}{1-e^{-F-M}}\right)\right]. \tag{H10}$$

<u>Case II: $p<q$</u>

For the case where $p<q$, analogues to Equations (H6-H10) appear as shown below:

$$\hat{N}_q = \hat{N}_0 e^{-F-Mq}, \tag{H11}$$

$$\hat{N}_0 = \left(\frac{ae^{-(F+Mq)b}}{1-e^{-F-M}}\right)^{\frac{1}{1-b}}, \tag{H12}$$

$$\frac{\hat{N}_0}{N_0} = e^{-(1-q)F\left(\frac{b}{1-b}\right)}, \tag{H13}$$

$$\frac{\hat{C}}{C} = \left(\frac{F+M}{F+Mp}\right)\left(\frac{1-e^{-F-Mp}}{1-e^{-F-M}}\right)e^{-(1-q)F\left(\frac{b}{1-b}\right)}, \tag{H14}$$

and

$$q^{*} = 1-\left(\frac{1}{F}\right)\left(\frac{1-b}{b}\right)\ln\left[\left(\frac{F+M}{F+Mp}\right)\left(\frac{1-e^{-F-Mp}}{1-e^{-F-M}}\right)\right]. \tag{H15}$$

Note that Case II Equations (H11-H15) are equivalent to their Case I counterparts (Equations (H6-H10), respectively) when $q=p$. Furthermore, Case I Equations (H8) and (H9) give the same answers as Case II Equations (H13) and (H14) if the q value used in the former pair is replaced by a value equal to $1-q(1-p)/p$.

As with Case I Equations (H8) and (H9), Case II Equations (H13) and (H14) indicate that equilibrium stock size and recruitment are always reduced under Management Option (b), but that equilibrium catch may be lower or higher than would be observed under Management Option (a). The relative gain under Management Option (b) implied by Equations (H9) and (H14) is plotted as a function of p in Figure H1 for various levels of F. Whenever the prevailing levels of b, F, M, and q allow Equations (H9) and (H14) to give values less than 1.0, the relative gain is minimized at $p=q$. The relative gain at $p=q$ is plotted as a function of b in Figure H2 for various levels of F.

Figures

H1) Relative gain from concentrated harvest. The vertical axis measures the relative catch increase (in numbers) resulting from early-season concentration of fishing effort. Parameter values used to generate this figure were b=0.32, M=0.3, and q=0.25.

H2) Relative gain from concentrated harvest at $p=q$. Parameter values used were b=0.32, M=0.3, and q=0.25.

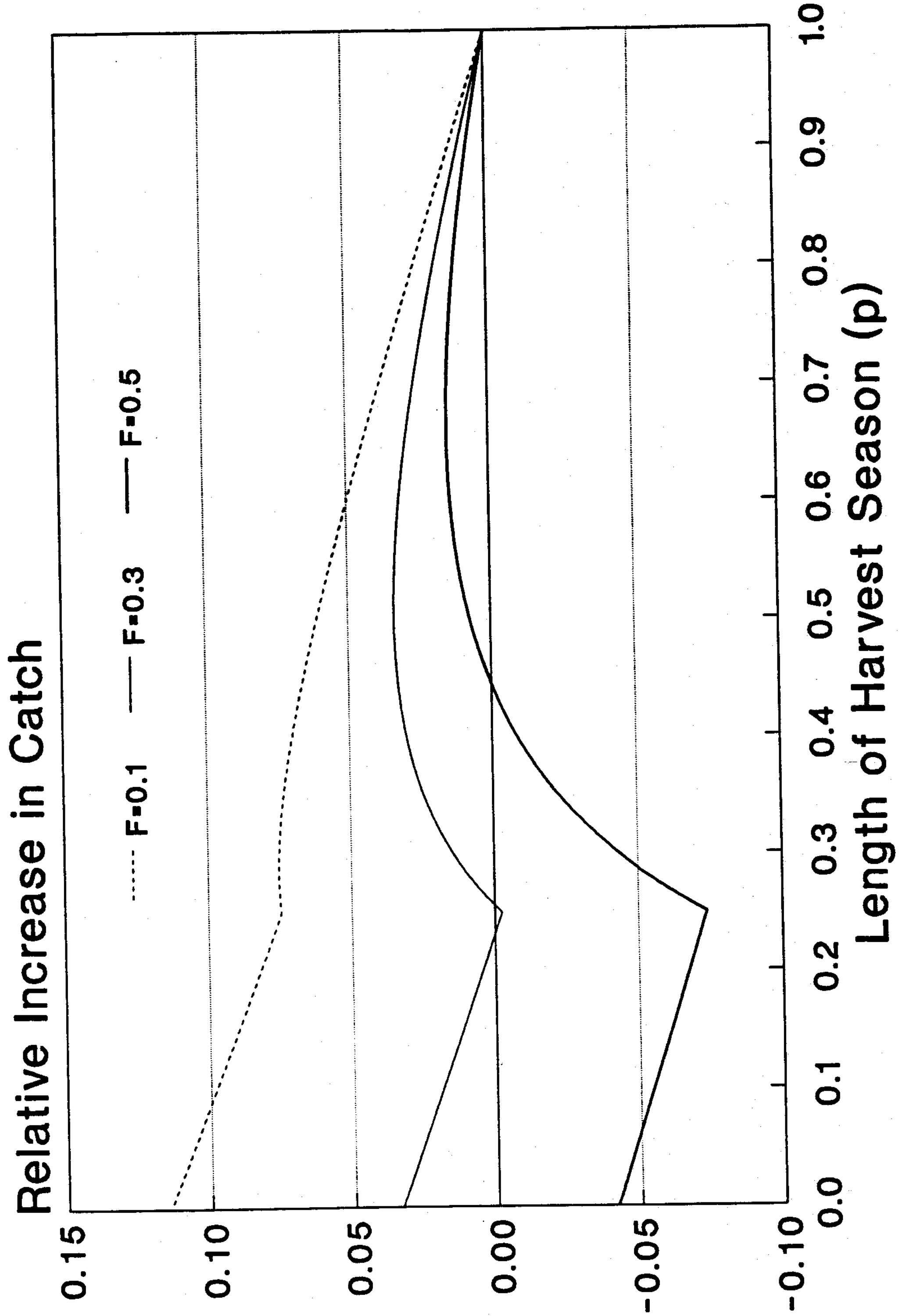
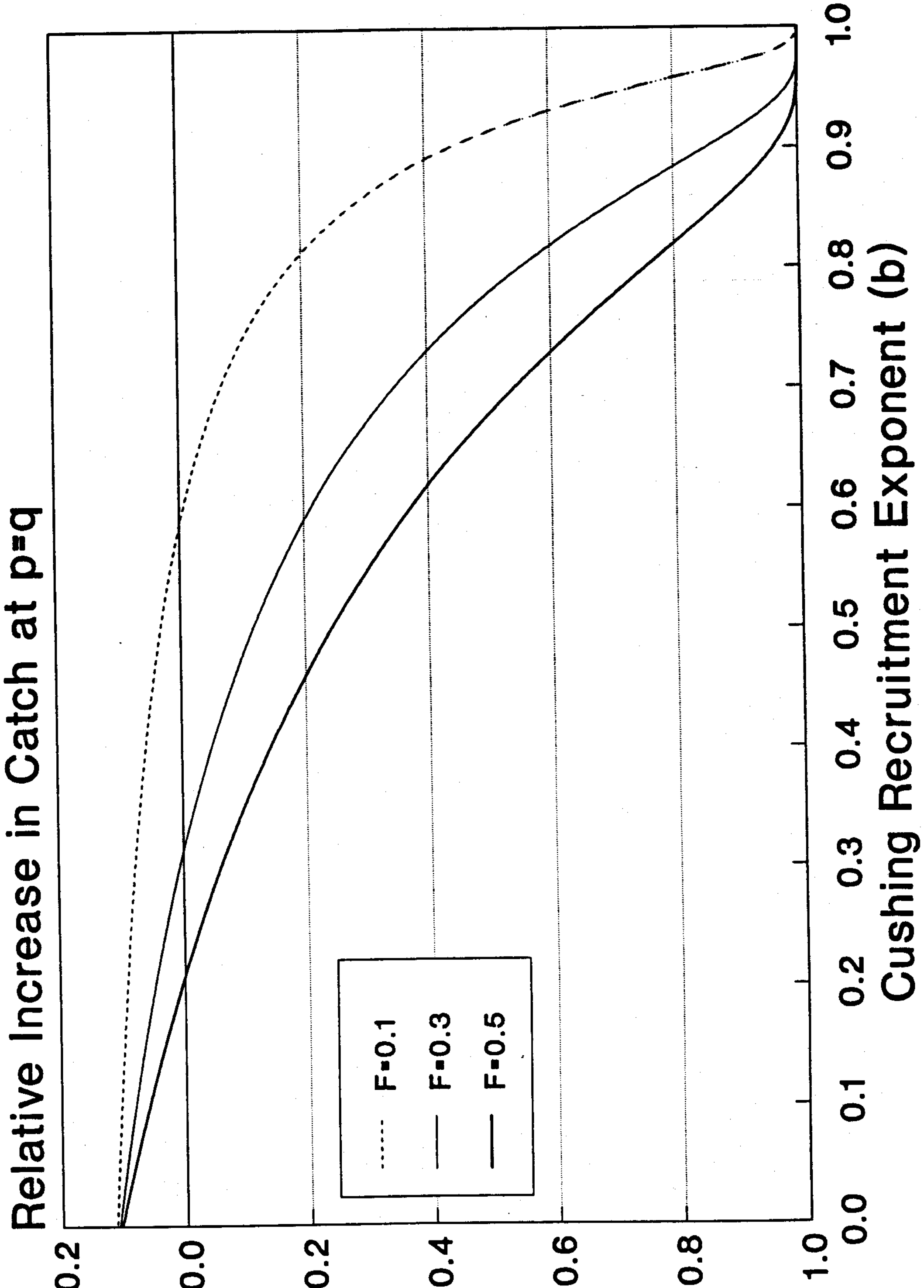

Relative Increase in Catch
F=0.1
F=0.3
F=0.5
0.15
0.10
0.05
0.00
-0.05
-0.10
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Length of Harvest Season (p)

Figure H1.



Relative Increase in Catch at p=q
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Cushing Recruitment Exponent (b)
F=0.1
F=0.3
F=0.5

Figure H2.

APPENDIX I

ANALYSIS OF BSAI COD ALLOCATION FOR TRAWL AND FIXED GEAR AND CHANGES IN THE SEASONALITY OF THE COD FISHERIES WITH RESPECT TO MARINE MAMMALS

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Analysis of BSAI Cod Allocation by Gear with respect to Marine Mammals

The issue of allocating BSAI cod TAC between trawls and fixed (longline and pot) gear and how this may relate to marine mammals was investigated in the following ways:

1) Rates of recent (1991) incidental take by both gear types;

2) Locations fished by both gear types, especially with respect to Steller sea lion rookeries;

3) Temporal distribution of catch by both gear types; and

4) Bycatch and cod length-frequencies of both gear types.

This analysis was done without any knowledge of the proposed allocation alternatives; therefore, it should be considered a "qualitative" analysis of where, when, and how each gear type is fished, and in general, what are the interactions of each gear with marine mammals.

The primary conclusion of this analysis is that fixed gear tends to have less overlap with marine mammals than trawl gear, both in terms of what is caught but also where, when and how it is fished. However, there is no firm evidence that allocating cod TAC to trawls would, in and of itself, have measurable deleterious effects on marine mammals. But allocating cod to trawls, especially if it is combined with an inshore allocation in the BSAI, could affect those marine mammals (particularly pinnipeds) that forage in the southeastern Bering Sea from Amak to Unalaska Islands. This is a similar conclusion to one that was reached with respect to establishment of the Catcher Vessel Operational Area for pollock by Amendment 18.

1. Rates of Incidental Take

Both gear types have a low (or zero) rate of incidental take of marine mammals when used in the cod fishery. In 1991, there were no observed takes of marine mammals by pot or longline gear fishing for cod in the BSAI or GOA regions. Trawl gear had a total of 45 observed takes of marine mammals in the two regions, 41 of which occurred in the BSAI. The BSAI cod fishery had a total of 2 observed takes; an unidentified whale and an unidentified phocid in subarea 521.

NMFS lists (Federal Register 12 May 1992; 57:92) commercial fisheries according to frequency of takes of marine mammals; BSAI longline fisheries are in Category II (occasional incidental take of killer whales), while BSAI trawl and pot fisheries are in Category III (remote likelihood of incidental take). Placement of longline fisheries in Category II is due to the documented interaction between killer whales and the longline fishery for sablefish and turbot. Despite their inclusion in Category III, BSAI trawl fisheries have had documented interactions with 14 marine mammal species, including pinnipeds, cetaceans and otters. Pots have had no documented taking of any marine mammal.

Neither gear as currently fished in the cod fishery is likely to present a problem with respect to incidental takes of marine mammals. However, increased cod-fishing effort with longlines in the BSAI could increase the interaction potential with killer whales. But due to the documented (although at low rates) takes of a wide variety of marine mammals by trawl gear, fixed gear may have a slight edge here with respect to lower potential impact on marine mammals.

2. Locations fished by both gear types

Attached are charts showing cod pot, longline and trawl fishing locations in the BSAI for 1990-91 by 3, 4-month periods. Fishing locations for the three gear types are similar, but trawls tend to be fished more in the southeastern Bering Sea (north of Unimak Pass and Unimak Island) than do longlines. Effort is concentrated near the edge of the continental shelf up to 60°N latitude in the Bering Sea, and along the northern edge of the Aleutian Islands, especially Akun, Akutan, Unalaska, Umnak, Seguam, Amlia, Atka, Adak, and Attu Islands.

In 1990-91, trawls caught 14.5 and 12.7%, respectively, of their total cod catch within 20 miles of Steller sea lion rookeries in the BSAI, and most of this occurred in either the 1st (1991) or 2nd (1990) quarters. By contrast, between 1-2% of the longline-caught cod was captured within 20 miles of Steller sea lion rookeries in the BSAI in 1990 and 1991. The small amount of data available for pots for 1990 and 1991 yield different patterns: in 1990, 10% of the pot-caught cod were caught within 20 miles of rookeries, while in 1991 this increased to 69%.

Based on where cod is caught by each gear type, fixed gear again is given a slight edge over trawl gear for lower interaction potential with marine mammals. This is especially true when viewed in light of any potential inshore/offshore cod allocation (as was done in the GOA). Inshore cod trawlers out of Dutch Harbor rely heavily on areas north of Akun, Akutan, Unimak Island and within Unimak Pass for catches, especially early in the year. This group was particularly affected by the 20 mile trawl closures around Akun and Akutan during the A season 1992. If an inshore cod allocation is granted in the BSAI or if the trawl allocation in this proposal is high, then conflict between cod trawling and marine mammals (particularly Steller sea lions) in this area will likely intensify.

3. Temporal distribution of catch

Trawl catch of cod has occurred primarily in the first half of both 1990-1991, with approximately 80% of the annual total harvested in the first two quarters (observer data). This may be due to the quarterly allocation schedule of halibut bycatch to the cod trawl fishery: 60% in quarter 1, 30% in quarter 2 and 10% in quarter 3.

By contrast, longline fishing for cod is spread more evenly throughout the year. Based on observer data, the quarterly percentage catch distribution of longline-caught cod in 1990-91 was:

	1990	1991
Quarter 1	9.5%	20.1%
Quarter 2	24.3%	27.1%
Quarter 3	36.3%	29.0%
Quarter 4	29.9%	23.8%

No records of cod pot deployments in Jan-Apr of 1990 or 1991 exist in NORPAC, suggesting that it is primarily a summer/fall fishery.

Based on the temporal distributions of the fisheries, again the slight edge goes to fixed gear. Winter is thought to be a more critical time period for foraging problems, especially for juvenile sea lions. While juvenile sea lions are unlikely to eat large cod, trawl fishing in the winter would more likely negatively affect foraging sea lions (fish school disruption, bycatch of other prey) than if fixed gear deployments were concentrated in winter.

4. Bycatch and cod length-frequencies

Cod generally comprise only a modest proportion of the sea lion diet, and less of the harbor seal's and Northern fur seal's. In the 1970s and 1980s, cod was found in 12.4% and 6.8% of the sea lion stomachs examined from the GOA (Calkins and Goodwin 1988), but was ranked second in order of importance (behind pollock) in a 1981 collection of sea lions from the Bering Sea (principally northwest of the Pribilofs; Calkins, unpubl.). Cod was found in 6-8% of the harbor seal stomachs examined from the GOA (Pitcher 1980a;b), and is a minor component of the fur seal diet (Kajimura 1984). All three pinnipeds tend to prefer smaller prey than adult cod, but 60-80 cm fish are not uncommon prey of sea lions. The average length of fish ingested by sea lions in several studies, though, has been under 30 cm.

Other important prey items of Steller sea lions, harbor seals, and Northern fur seals include pollock, herring, squid, octopus, Atka mackerel, capelin, sand lance and salmon. Bycatch rates of the two gear types for these species would also affect the degree of interaction with these pinnipeds.

Bycatch

Of the eight pinniped prey items listed above, pollock and Atka mackerel are caught almost exclusively by trawls in directed fisheries. Furthermore, bycatch rates of pollock, particularly small pollock, are much lower with fixed gear than with trawls. Bycatch rates of capelin and sand lance are very low in groundfish fisheries regardless of gear type. Table 1 (below) summarizes the 1991 bycatch rates of cod-directed trawls and fixed gear for squid, herring, octopus, salmon and prohibited species. Directed cod fishing for each gear type was defined as follows:

Trawls: Cod ≥ 40% of retained catch after midwater pollock (pollock ≥ 95% of total catch) and Greenland turbot (turbot ≥ 35% of retained catch) trawl fisheries had been assigned. Retained catch was the total catch of all species with assigned TACs.

Fixed gear: Cod ≥ 40% of retained catch of all species with assigned TACs.

Table 1. Observed bycatch rates of squid, herring, octopus, salmon and prohibited species by trawls and fixed gear fishing for cod in the BSAI in 1991.

Catch	Trawl	Fixed
Total (mt)	56,103	70,025
Retained (mt)	52,939	61,823
Cod (mt)	40,066	57,967
Squid (kg)	2,931	0
rate (kg/mt cod)	0.073	0
Herring (kg)	1,316	0
rate (kg/mt cod)	0.033	0
Octopus (kg)	57,722	92,710
rate (kg/mt cod)	1.441	1.599
Salmon (kg)	11,212	295
rate (kg/mt cod)	0.280	0.005

Halibut (kg)	922,495	2,430,055
rate (kg/mt cod)	23.024	41.922
King crab (#)	2,105	4,202
rate (#/mt/cod)	0.052	0.072
Tanner crab (#)	380,023	99,433
rate (#/mt cod)	9.485	1.715

Bycatch rates of squid and herring by cod trawls and fixed gear were low, but fixed gear had no observed bycatch of either species. Octopus bycatch rates for both gear types were the highest of the four species, with fixed gear having slightly higher bycatch rates than trawls for octopus. As expected, salmon bycatch rates were considerably higher (56 times higher) for trawls than for fixed gear.

Fixed-gear bycatch rates of halibut are nearly double those of trawls, but discard mortality rates of halibut are much lower from fixed gear (13-18% for longlines and 6-10% from pots) than from trawls (75%). Using the observed bycatch rates of halibut by both gear types above, discard mortality of halibut would be approximately 17.3 kg/mt of trawl-caught cod, and range between 2.5 - 7.5 kg/mt of fixed gear-caught cod.

King crab bycatch rates were approximately the same by both gear types in 1991, while the trawl bycatch rate for Tanner crab was 5.5 times that of fixed gear.

In summary, with respect to bycatch rates of pinniped prey and prohibited species, fixed gear would be favored over trawl gear due to its zero bycatch of some important pinniped prey items (particularly squid, herring and small pollock) and lower discard mortality of prohibited species. Both gear types have relatively high bycatch rate of octopus, which could be a concern given the potential for an directed octopus fishery.

Cod Length-Frequency

Length-frequencies of cod collected by all trawls, cod-directed trawls and fixed gear in 1991 are shown on accompanying figures. Mean and median lengths of cod caught by both trawls and fixed gear were all greater than 65 cm, but were between 5-7 and 3-5 cm lower, respectively, for trawls than for fixed gear. More importantly, between 14-20% of the cod caught by trawls were 50 cm in length or less, while only 3% of the cod caught by fixed gear were in this size category in 1991. Fixed gear may have less potential for interaction with pinnipeds than trawls based on the length-frequency of cod captured.

Effects on Marine Mammals of Changing the Seasonality of the Cod Fisheries

Steller sea lions are a particular concern because they were listed as threatened under the Endangered Species Act in 1990 after declines of as much as 90% were observed in some areas off Alaska. Since then, their population has apparently continued to decline at the rate of approximately 5% per year based on aerial surveys conducted in summer, when pupping and breeding occur. The availability of forage fish species during weaning, which commences during the fall of the first year and continues throughout the winter, is thought to be critical for survival and eventual recruitment of pups into the adult population. Pups eat primarily small schooling fish, such as capelin, herring, or pre-recruited (to fisheries) pollock, cod and salmon.

It is not known to what extent fisheries, both directly (e.g. catches of fish) and indirectly (e.g. disturbance of sea lions and fish schools), affect the foraging ability of sea lions. The cod trawl and longline fisheries, which are conducted on the bottom (relatively low bycatch of small pelagic schooling fish) and generally catch fish larger than 35 cm, might have less effect on marine mammals, particularly Steller sea lions, than the pollock fishery, which has a higher bycatch of small schooling forage fish. Despite the uncertainties regarding direct fisheries effects, NMFS, in 1991-92, created year-round (10 nm radius) and seasonal (20 nm radius in the eastern Aleutian Islands during the pollock "A" season) trawl exclusion zones around all Steller sea lion rookeries in the Bering Sea, Aleutian Islands and Gulf of Alaska to provide refuge for sea lions from trawl fishing activity. These zones will be in place regardless of the change to the seasonality of the cod fisheries. It is too early to know to what extent the creation of these zones has benefited sea lions.

With all of the alternatives being considered, much of the cod harvest would occur during the fall and winter. This is the period when sea lion pups are being weaned and learning to forage on their own. It is unknown whether cod harvests and the associated bycatch during this period are detrimental to sea lions or other marine mammals. If the decline in the Steller sea lion population continues, more fisheries restrictions may be necessary. If further restrictions to fisheries are necessary, the option to framework the seasonal allocation would permit more regulatory flexibility with respect to actions that could be taken to protect marine mammals.

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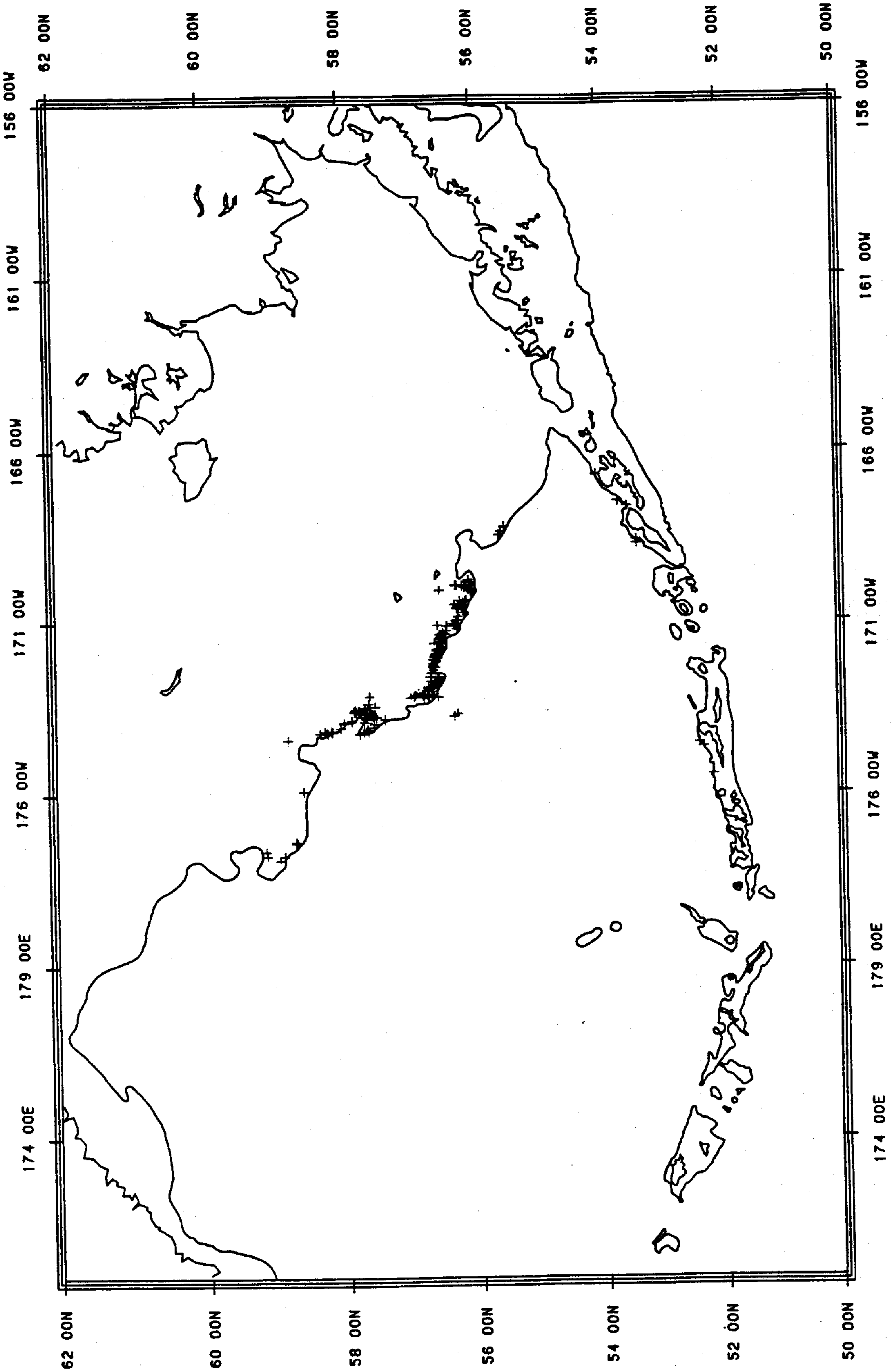
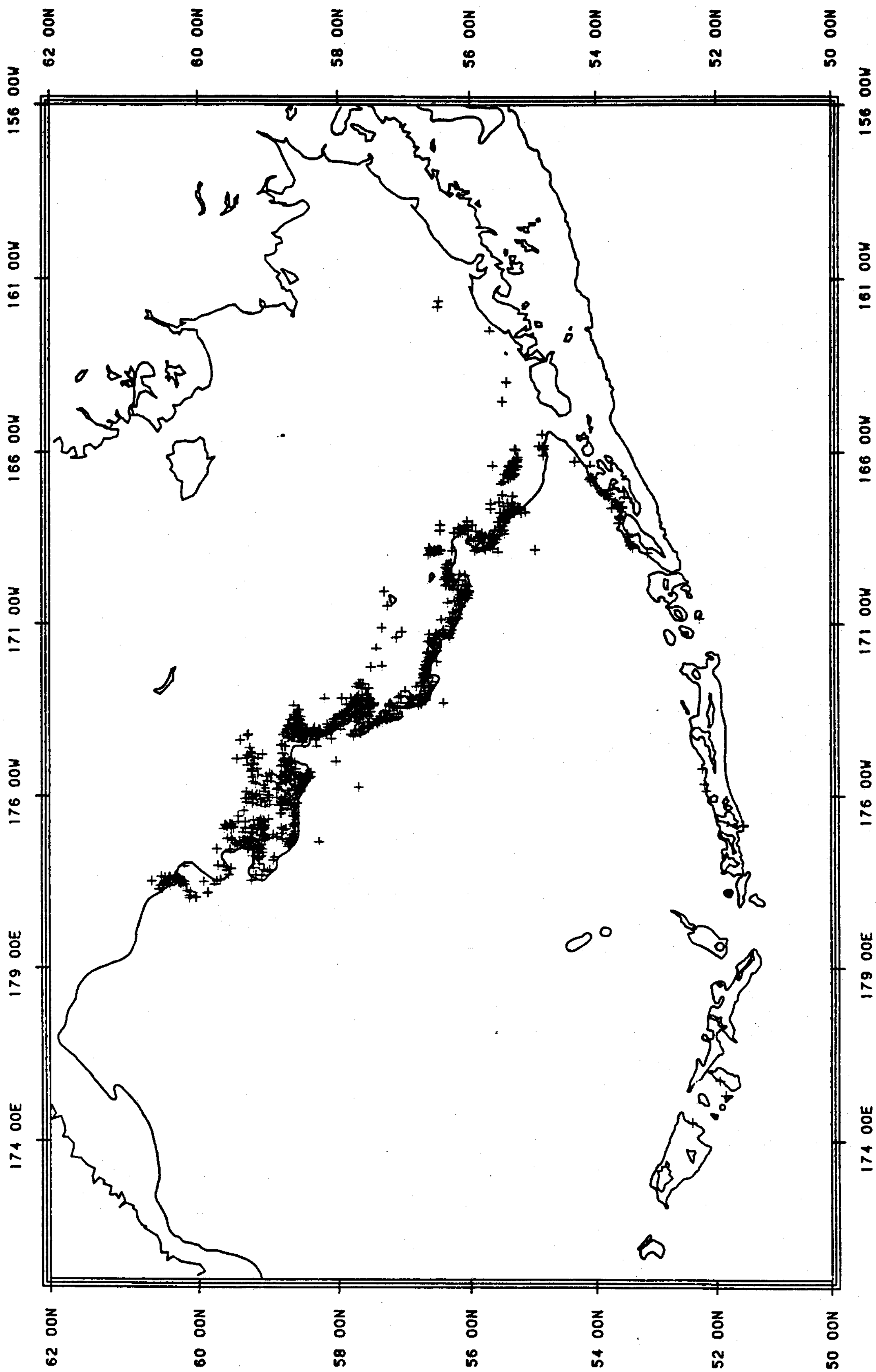


JAN-APR 1990 PACIFIC COD LONGLINE LOCATIONS



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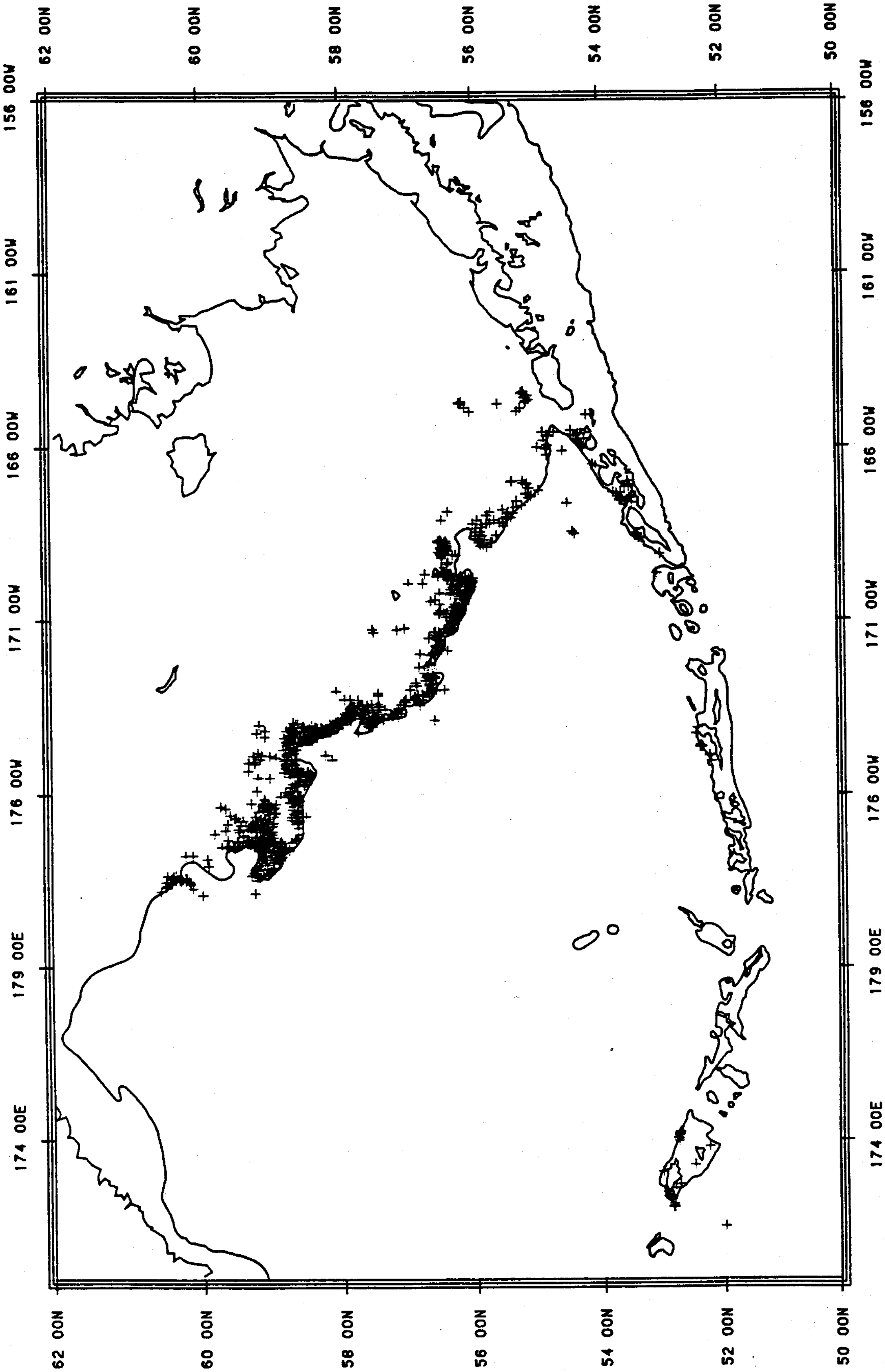

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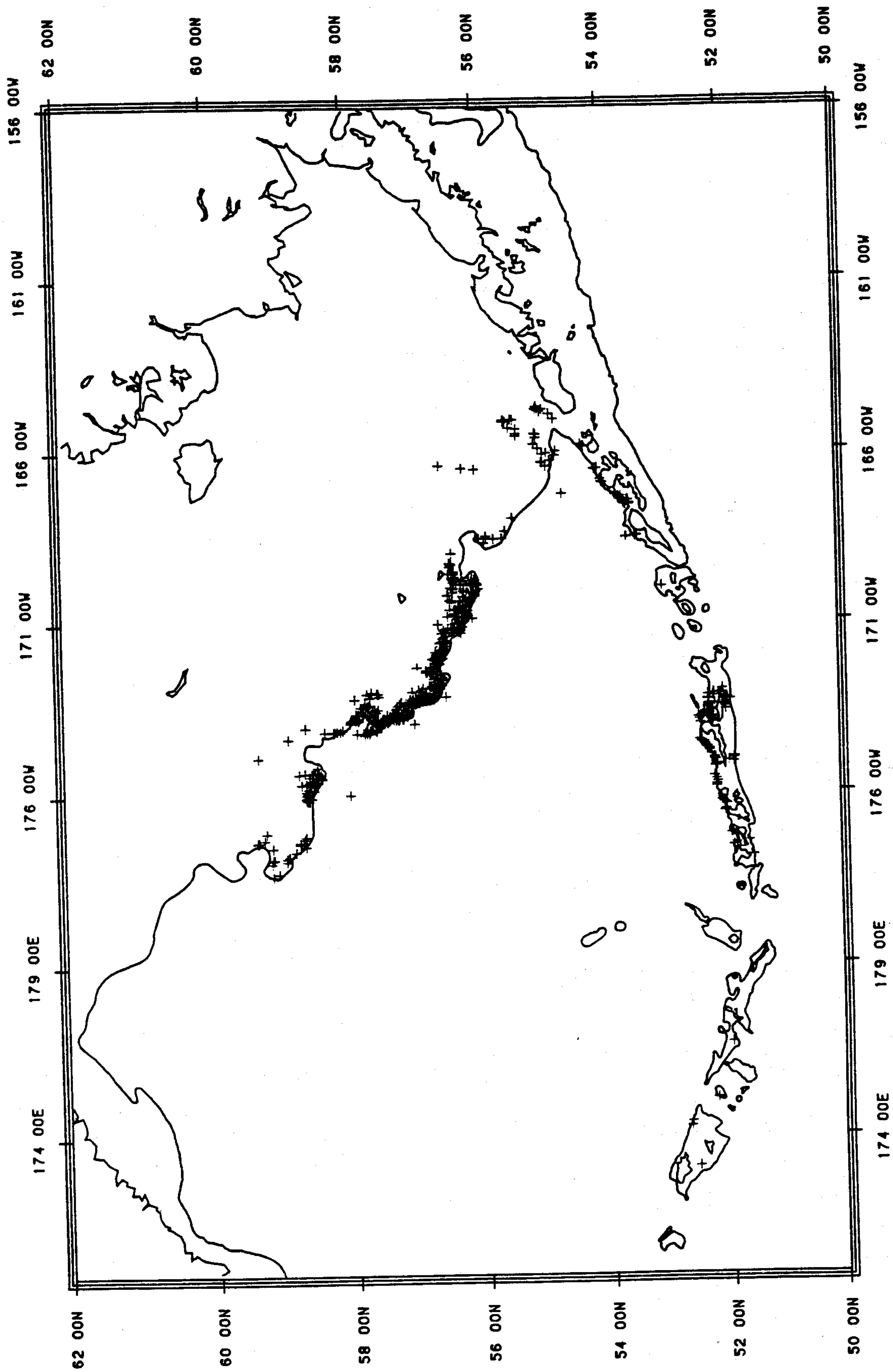
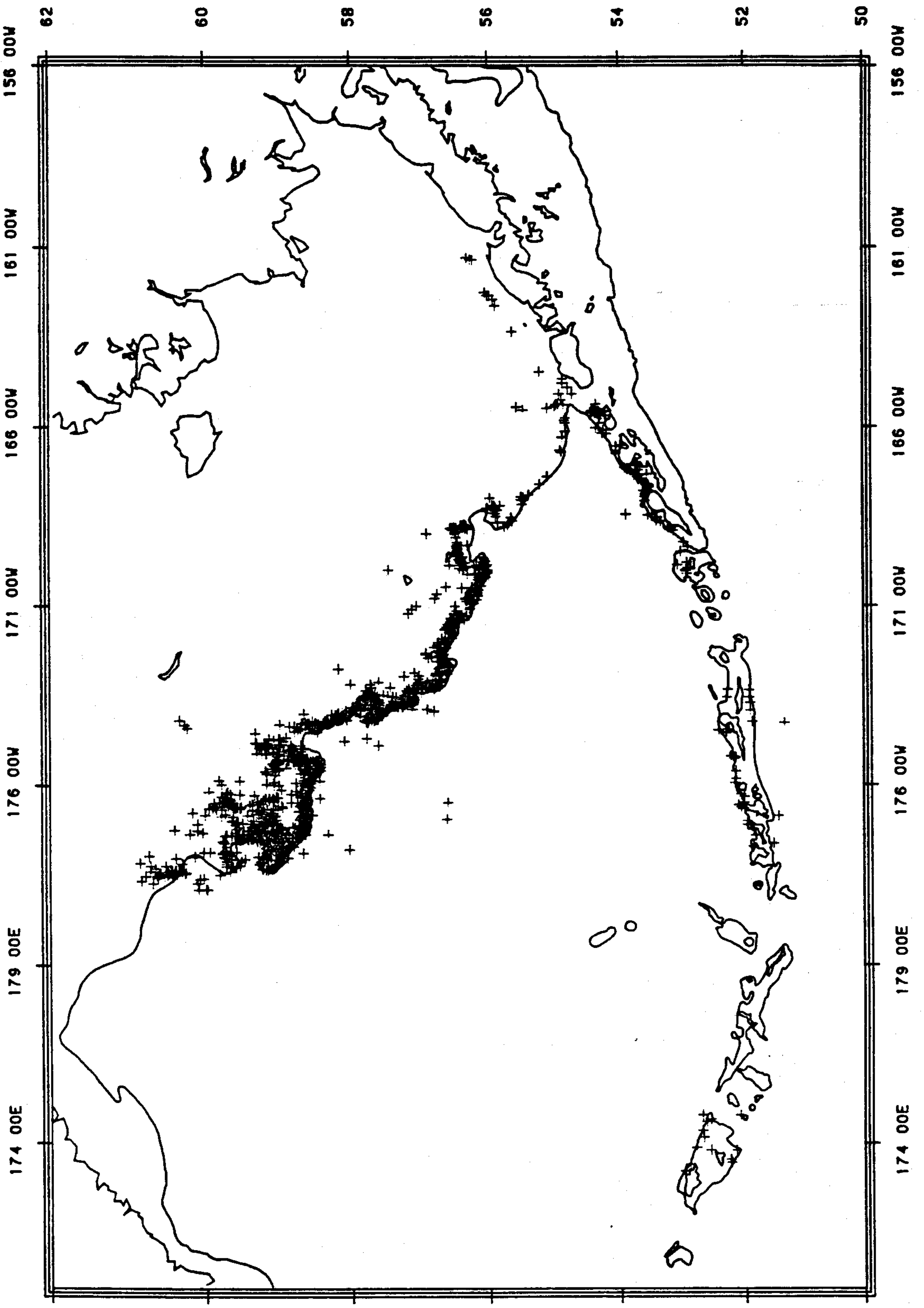
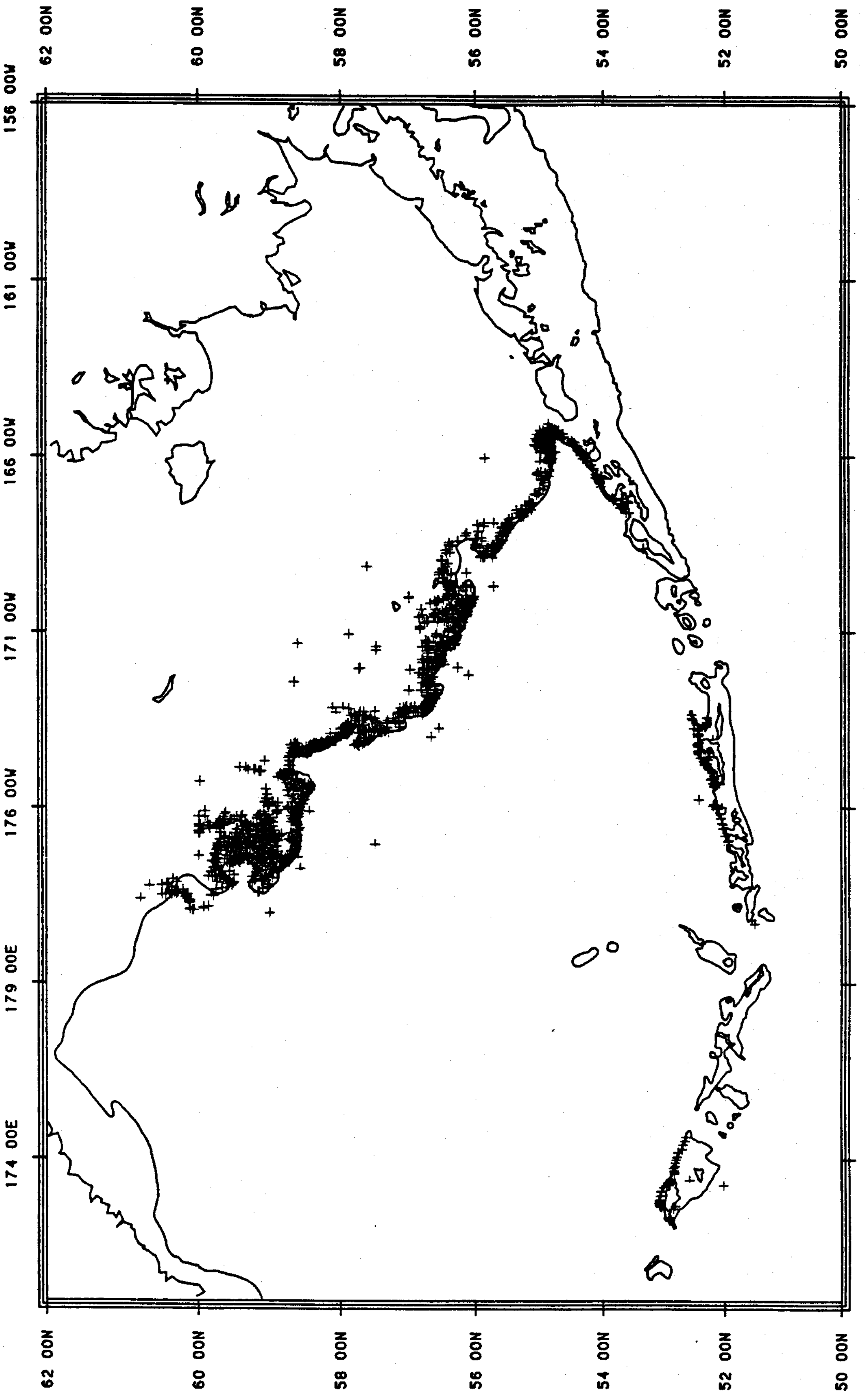


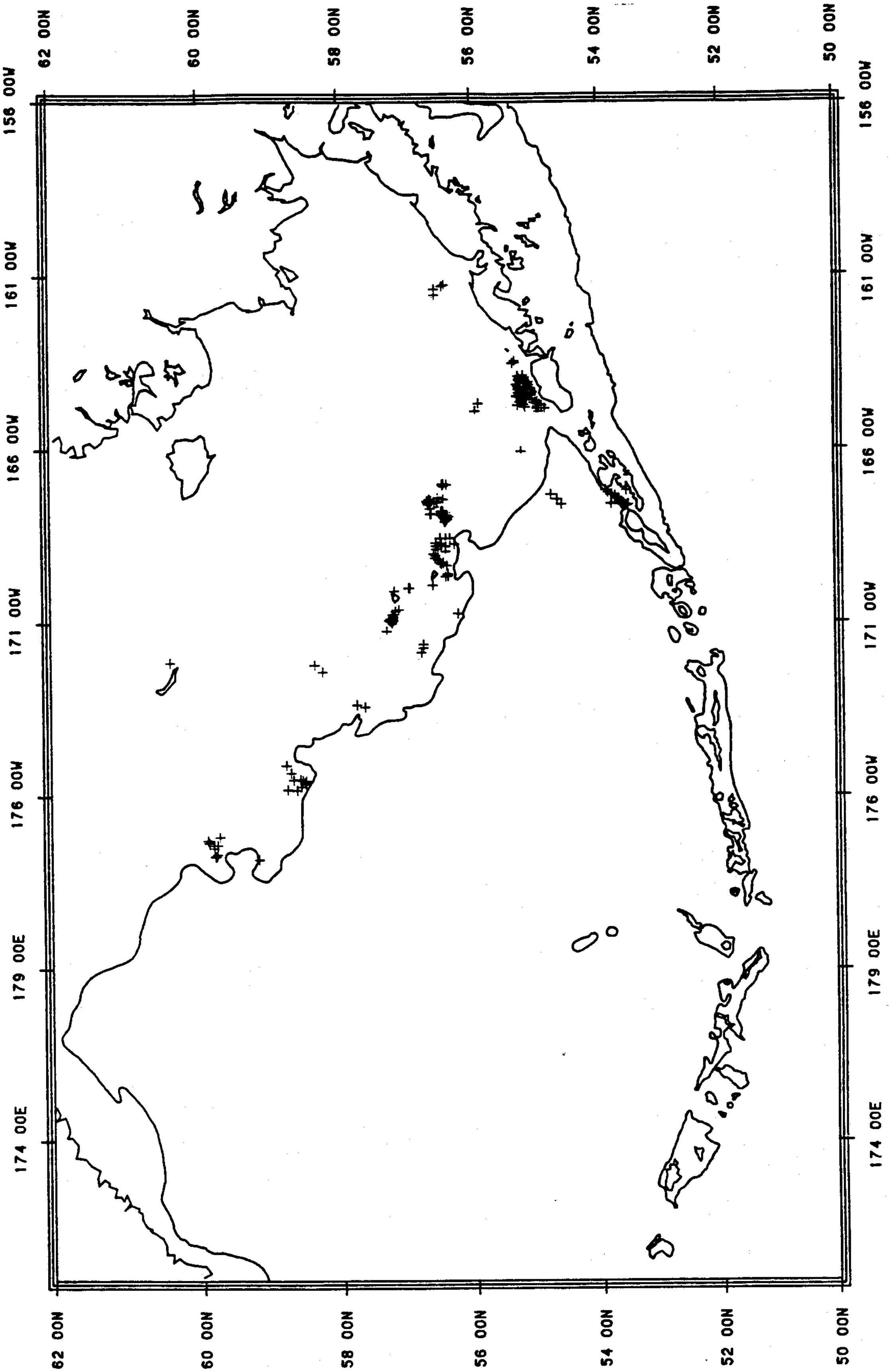
JAN-APR 1991 PACIFIC COD LONGLINE LOCATIONS



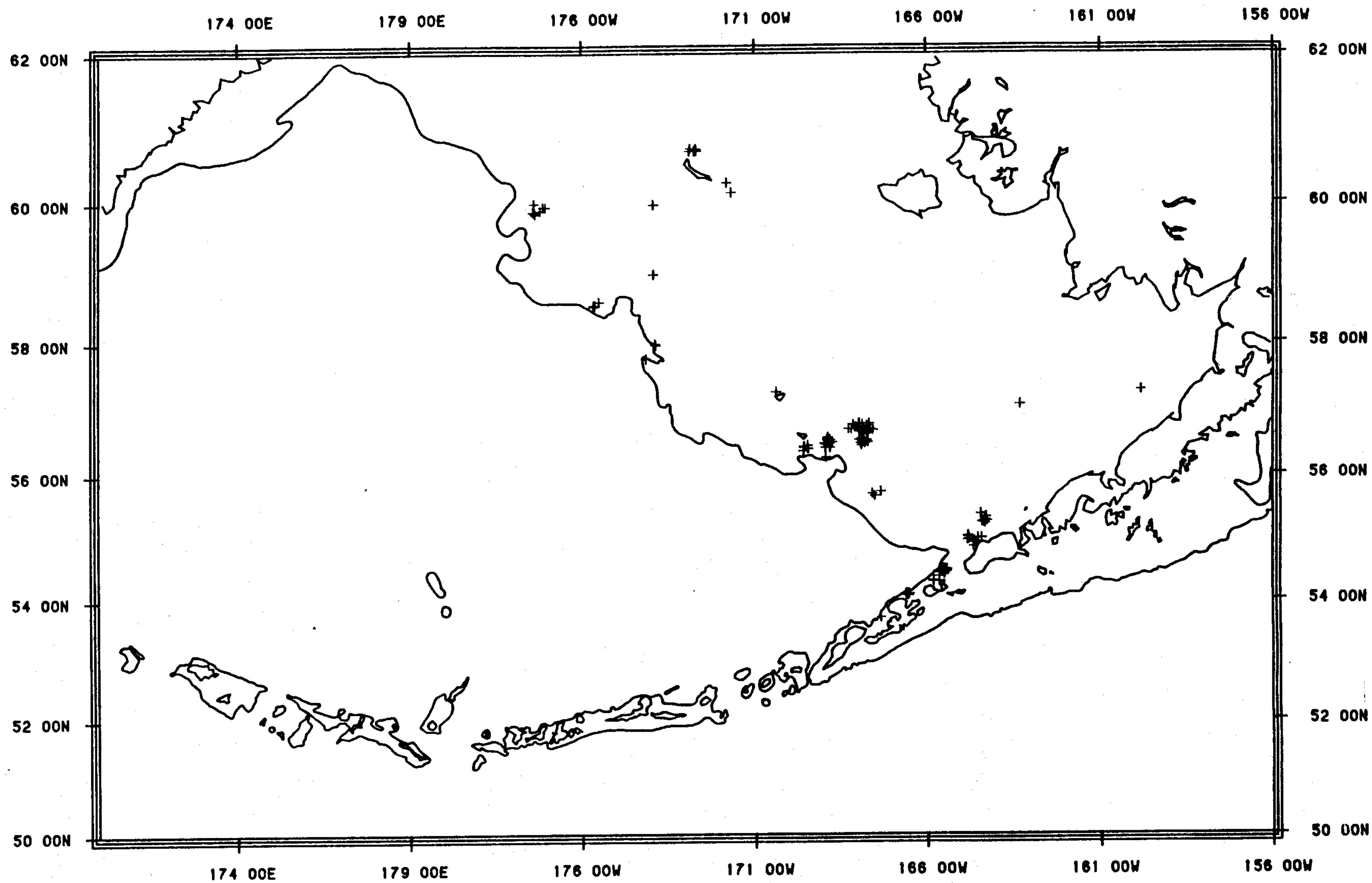
MAY-AUG 1991 PACIFIC COD LONGLINE LOCATIONS



SEP-DEC 1991 PACIFIC COD LONGLINE LOCATIONS



MAY-AUG 1990 PACIFIC COD POT LOCATIONS



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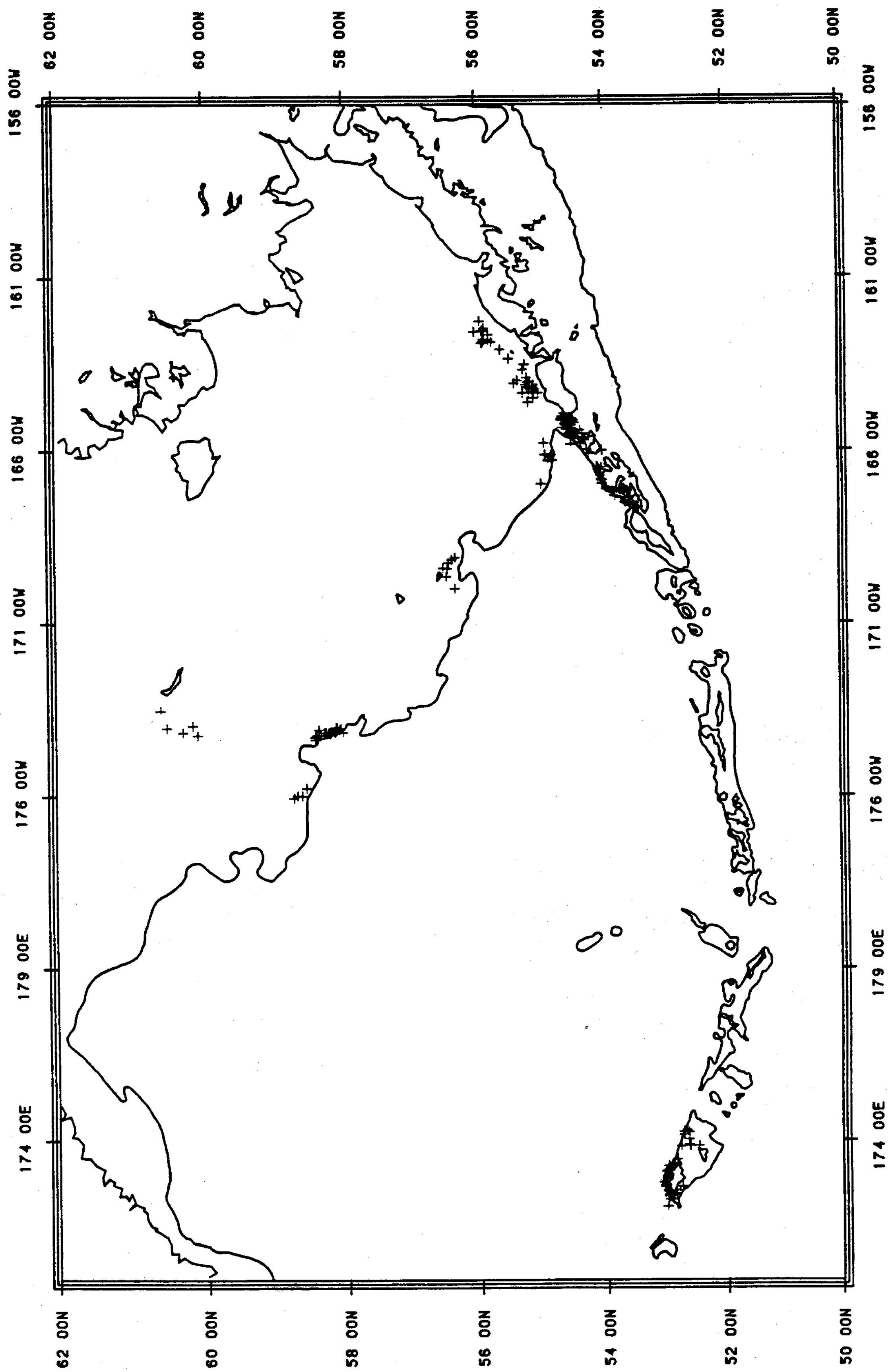

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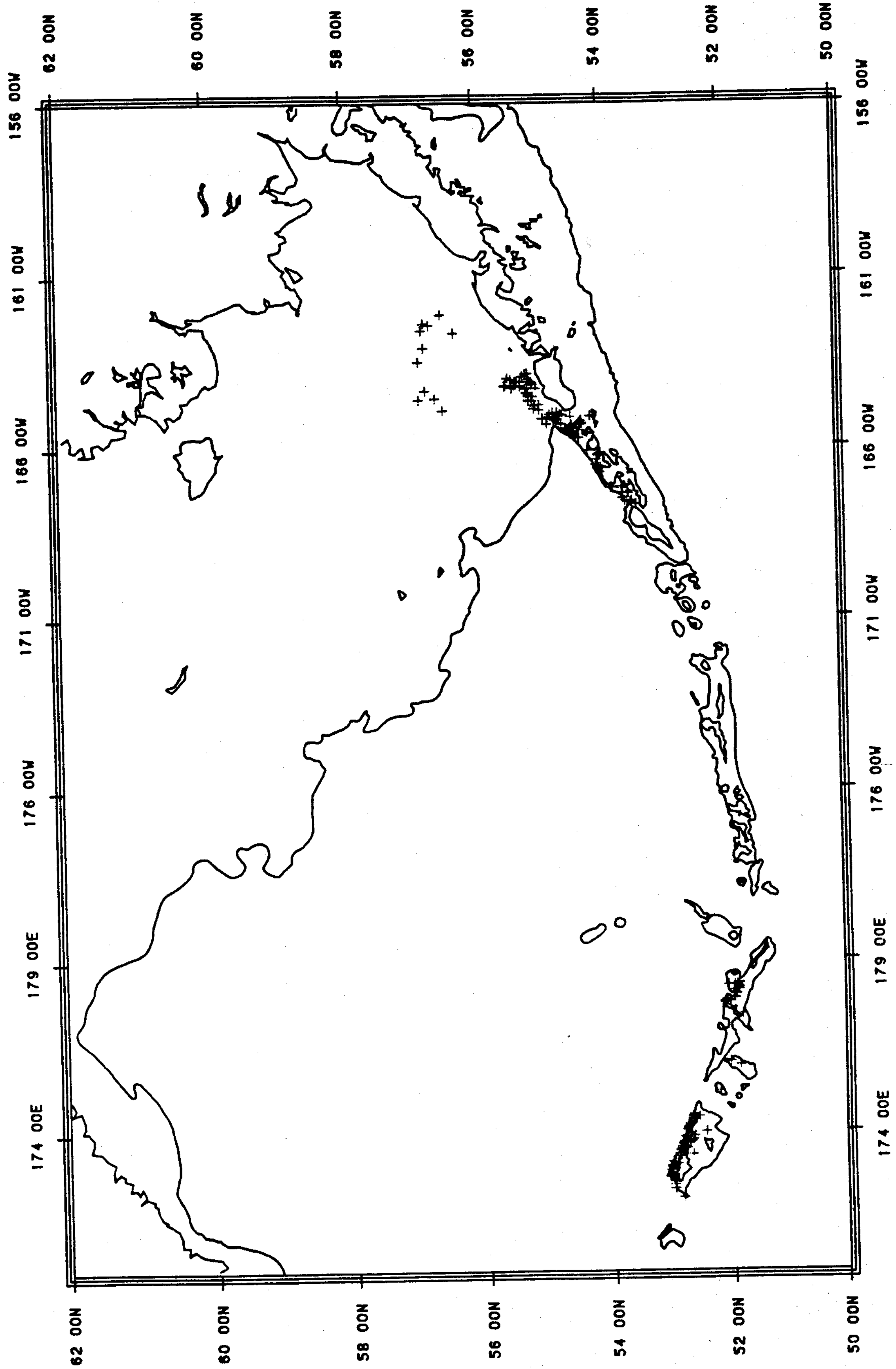
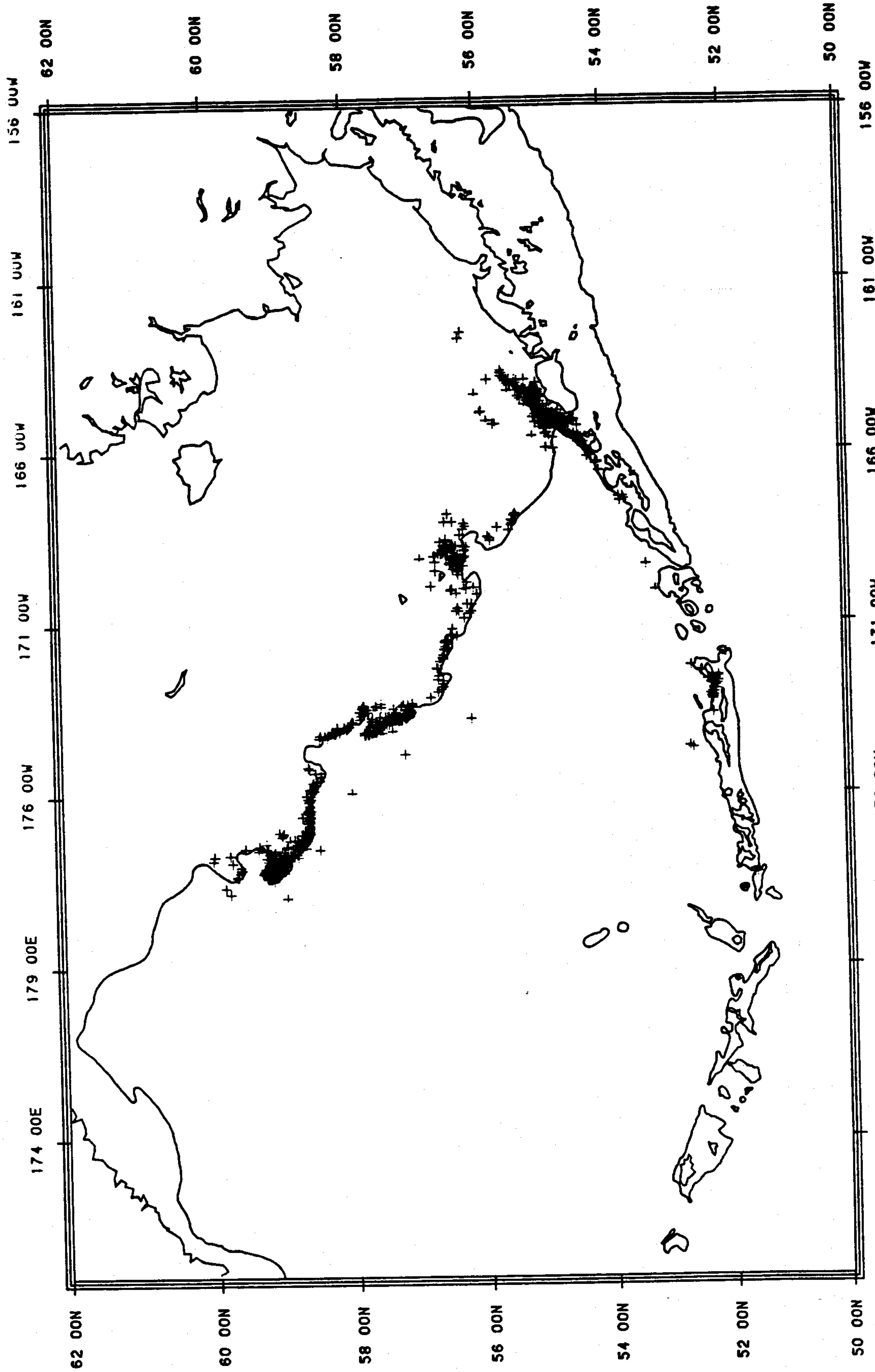
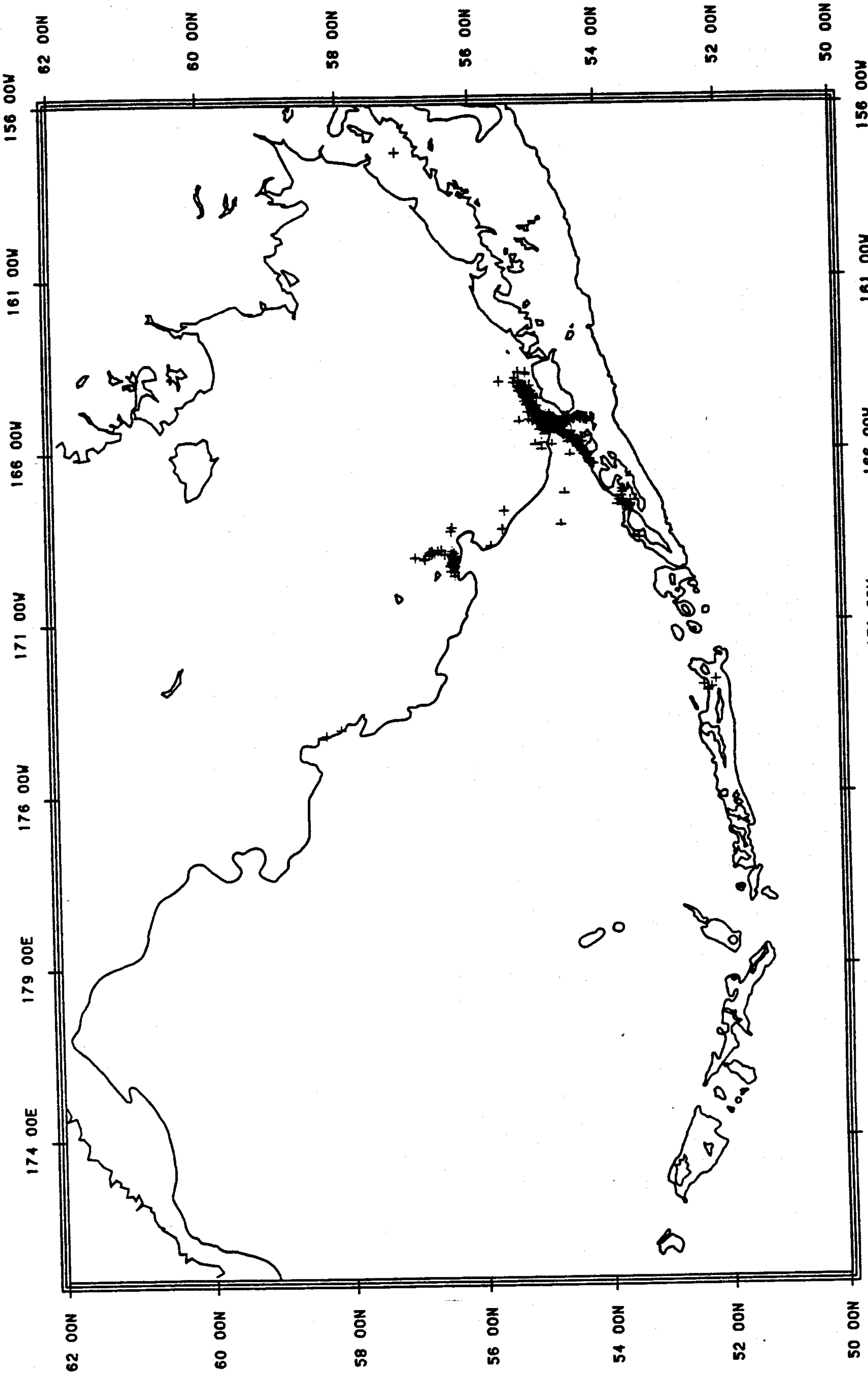


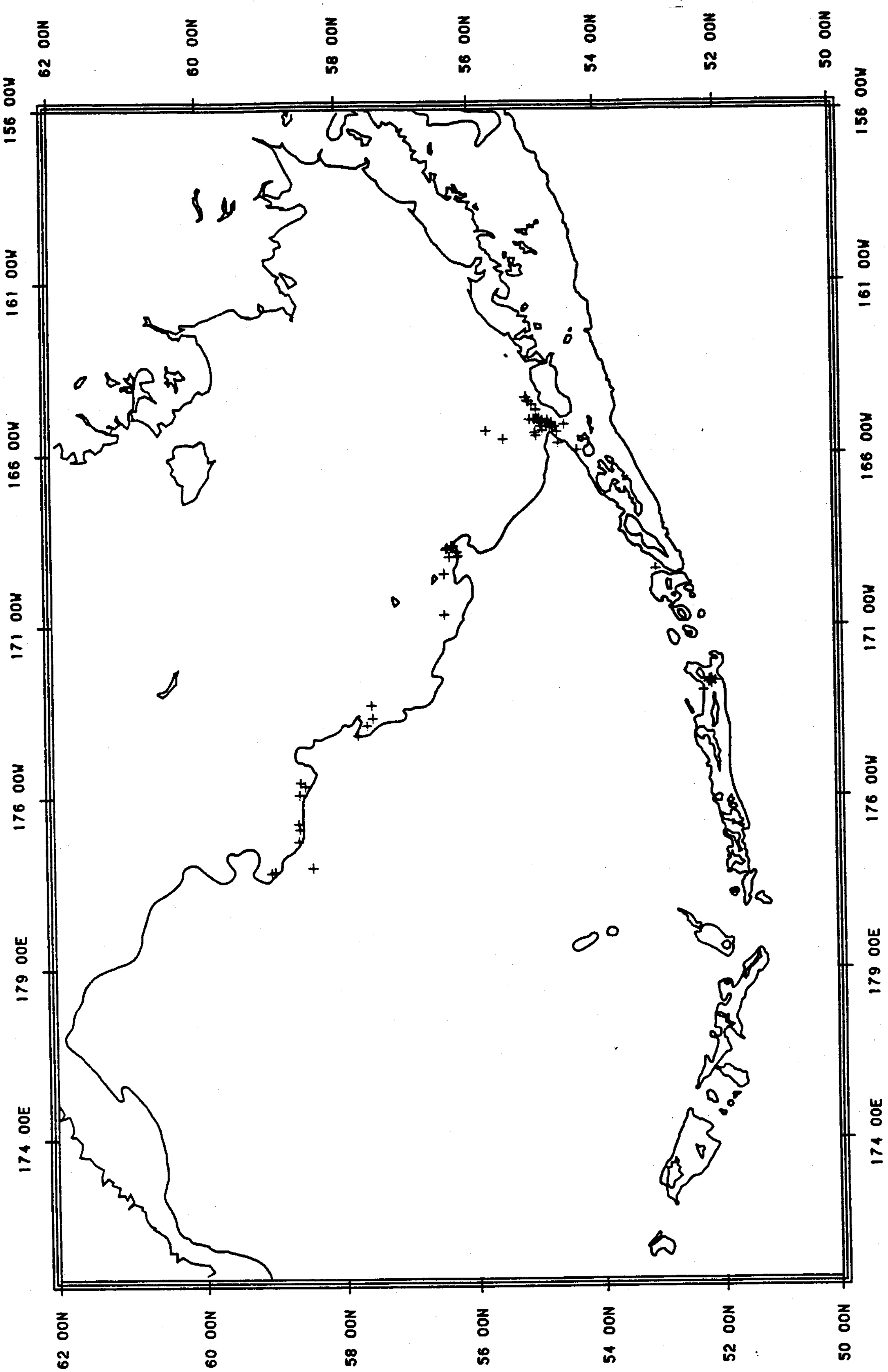
SEP-DEC 1991 PACIFIC COD POT LOCATIONS



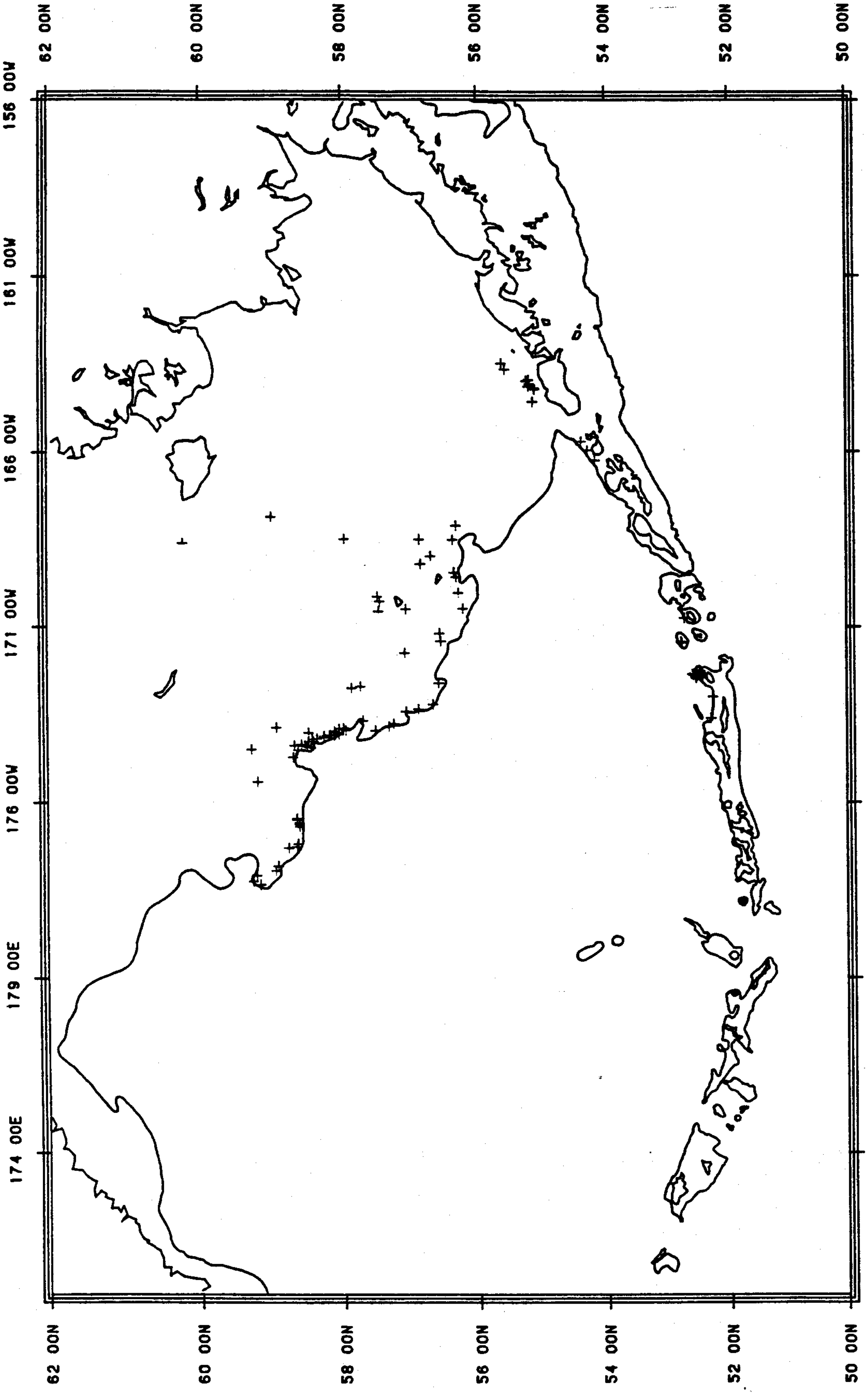
JAN-APR 1991. CATCHER/PROCESSOR COD TRAWL LOCATIONS



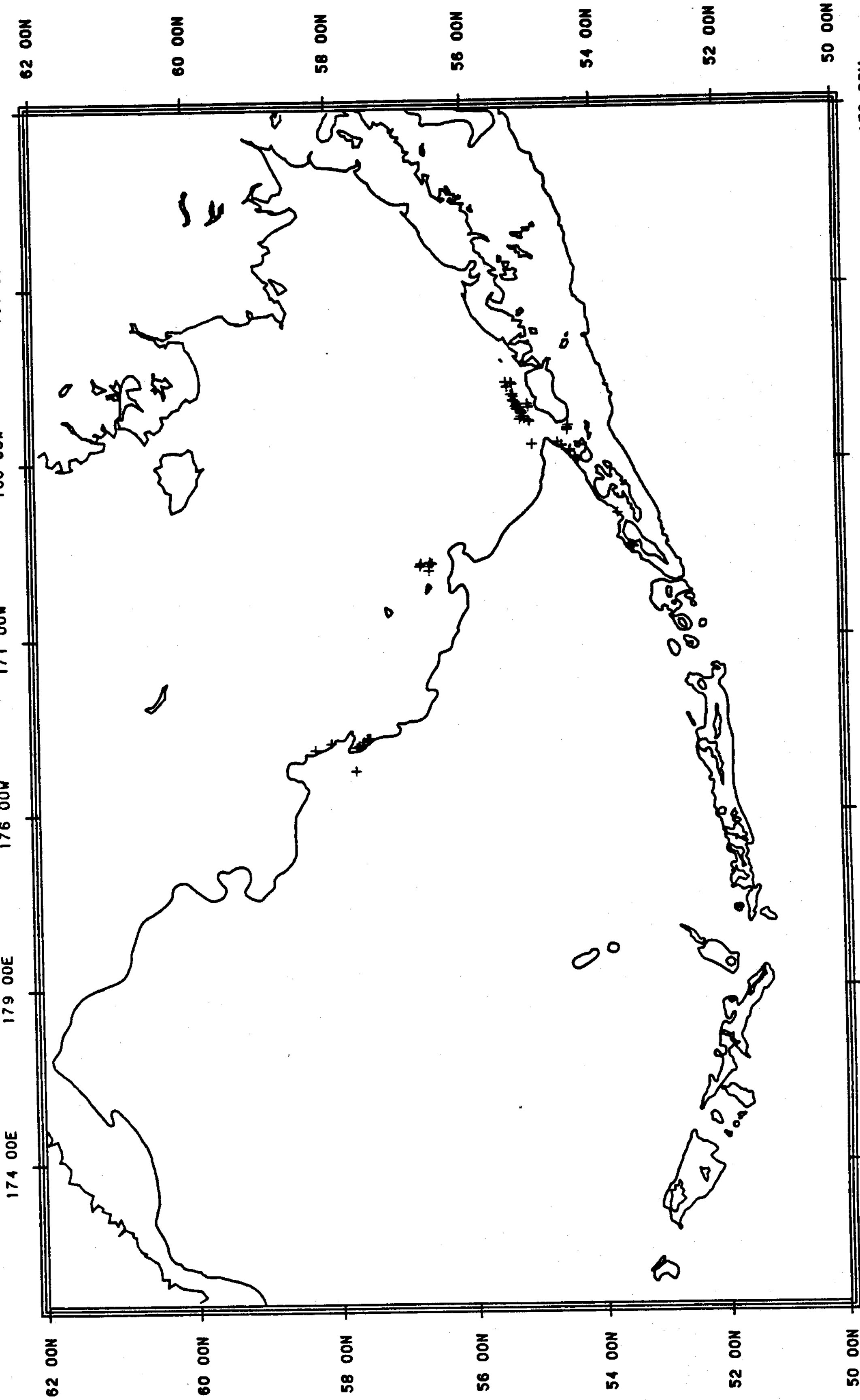
JAN-APR 1991. SMALL TRAWLERS COD TRAWL LOCATIONS



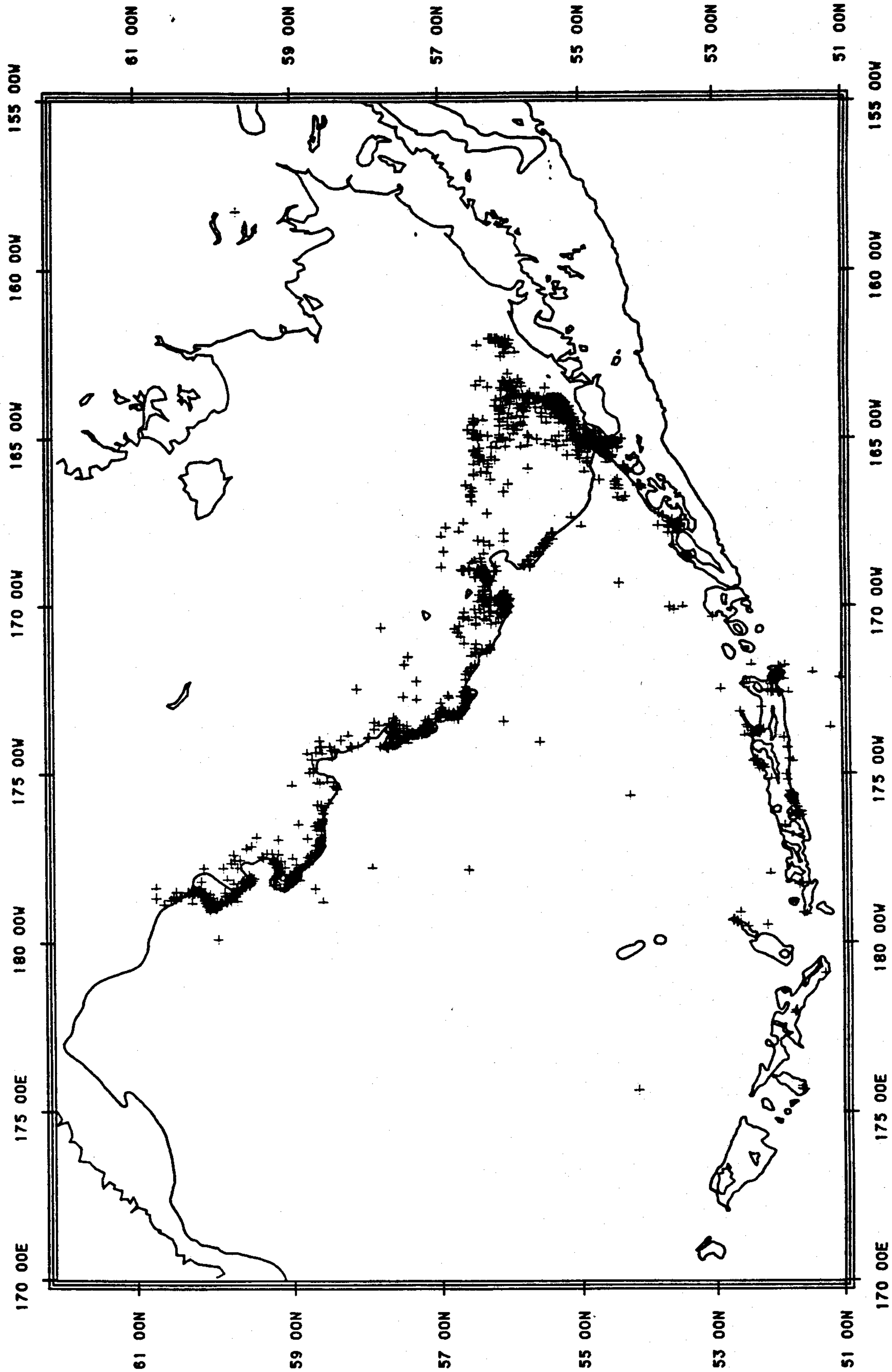
JAN-APR 1991. FL PROCESS/MOTHERSHIP COD TRAWL LOCATIONS



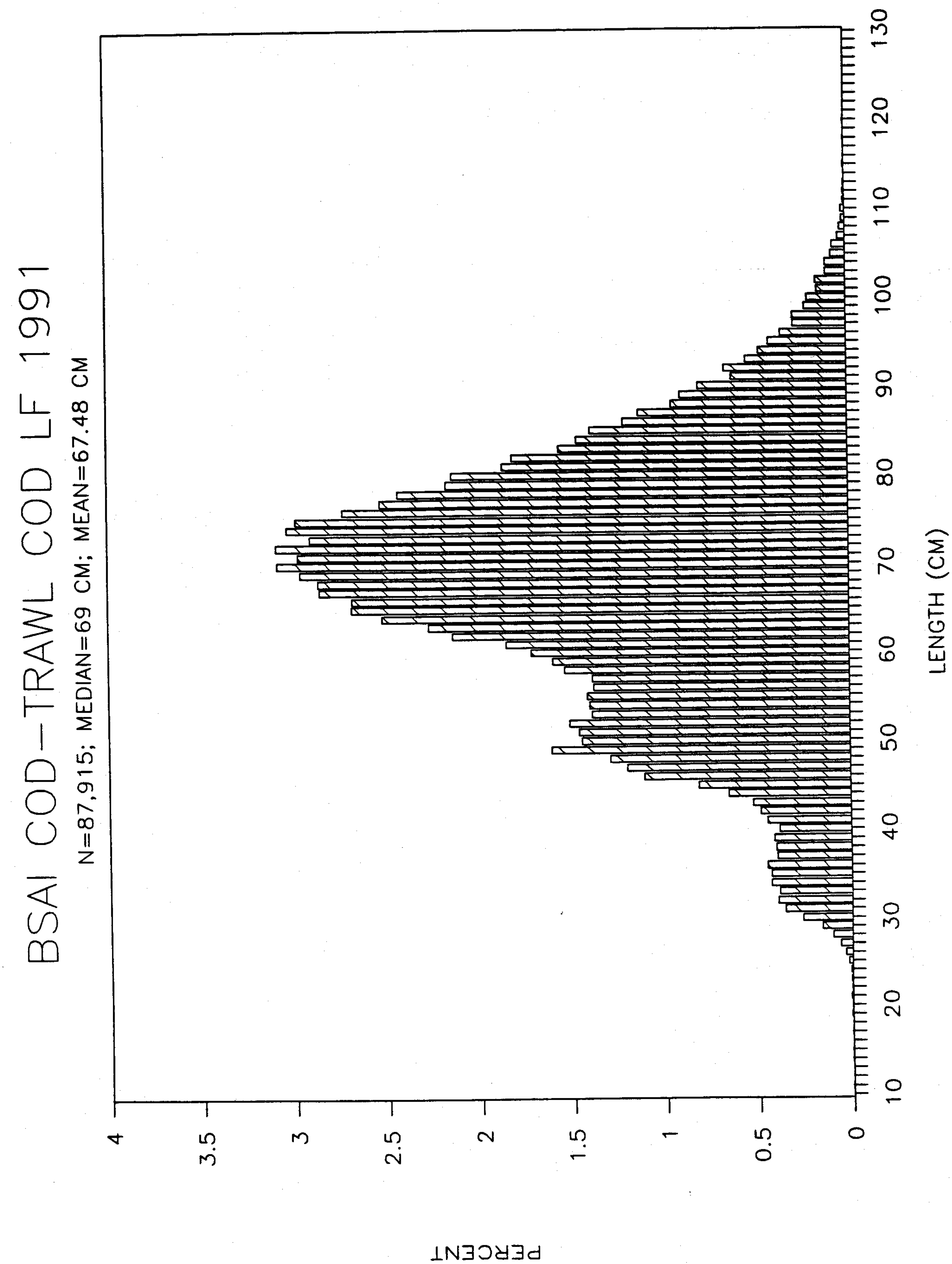
MAY-AUG 1991, CATCHER/PROCESSOR COD TRAWL LOCATIONS



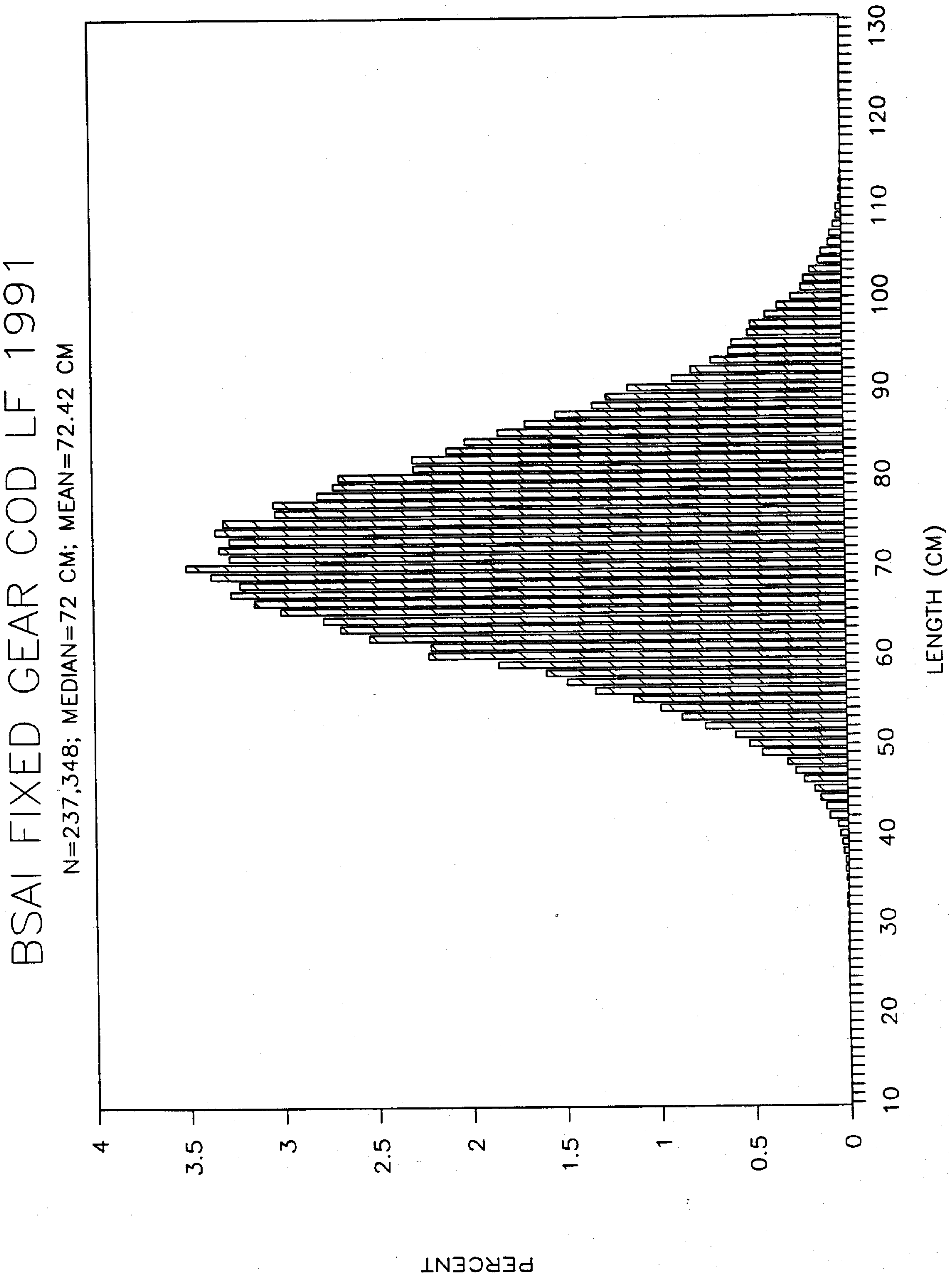
MAY-AUG 1991. SMALL TRAWLERS COD TRAWL LOCATIONS

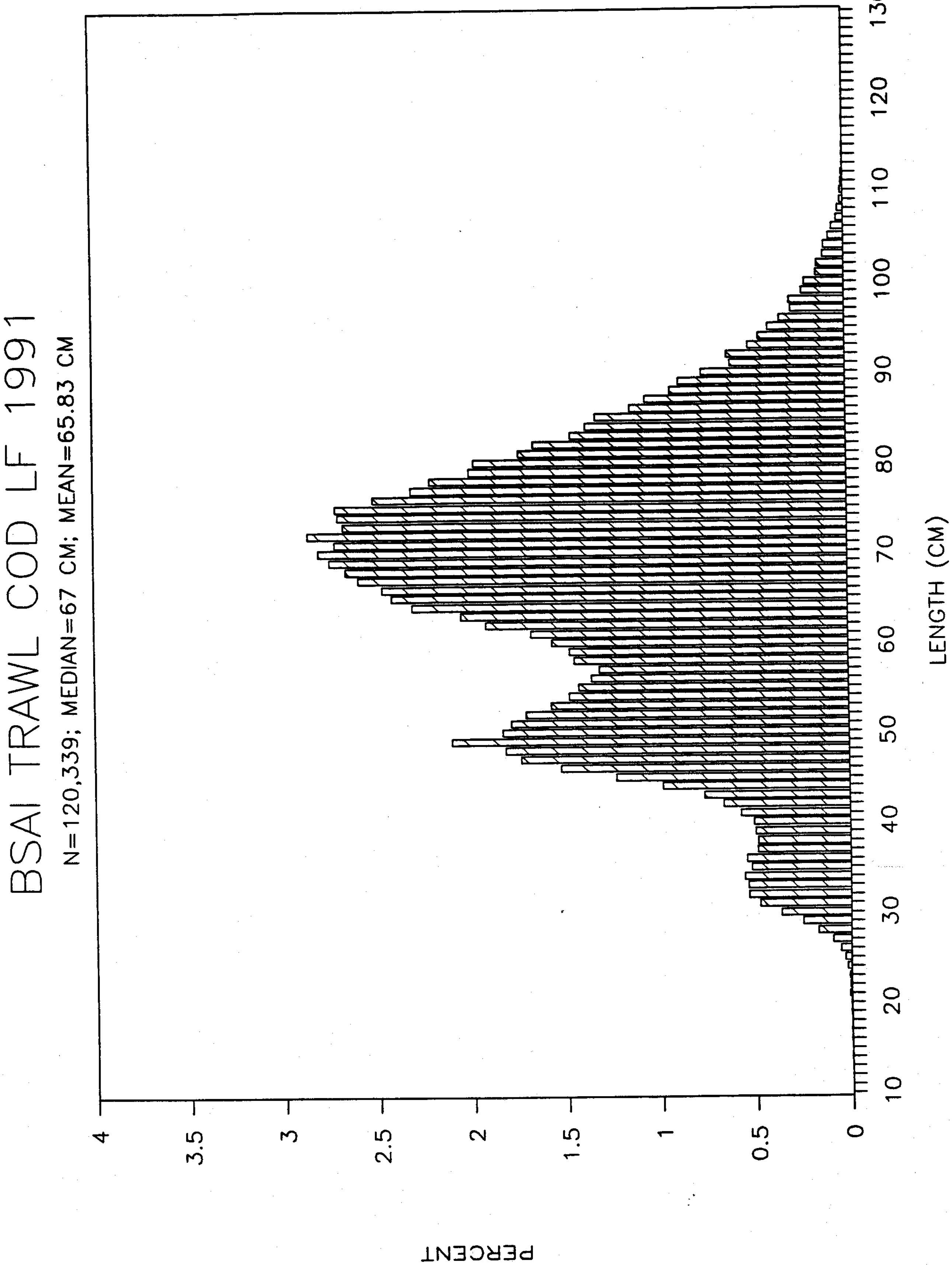


JAN-APR 1992. PACIFIC COD TRAWL LOCATIONS



BSAI COD—TRAWL COD LF 1991
N=87,915; MEDIAN=69 CM; MEAN=67.48 CM
PERCENT
LENGTH (CM)
0
0.5
1
1.5
2
2.5
3
3.5
4
10
20
30
40
50
60
70
80
90
100
110
120
130


BSAI FIXED GEAR COD LF 1991
N=237,348; MEDIAN=72 CM; MEAN=72.42 CM
PERCENT
0
0.5
1
1.5
2
2.5
3
3.5
4
LENGTH (CM)
10
20
30
40
50
60
70
80
90
100
110
120
130


BSAI TRAWL COD LF 1991
N=120,339; MEDIAN=67 CM; MEAN=65.83 CM
PERCENT
LENGTH (CM)
0
0.5
1
1.5
2
2.5
3
3.5
4
10
20
30
40
50
60
70
80
90
100
110
120
130